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PRICE EXPECTATIONS AND NOMINAL
INTEREST RATES IN CANADA

by



RAJNI SARNA

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ABSTRACT

According to Fisher, nominal interest rates consist of two components, the real rate of interest and the expected rate of inflation. The purpose of this study is the empirical investigation of the effect of the expected rate of inflation on nominal interest rate in Canada over the period 1951 to 1968. This was done within the framework of a model of interest rate determination which explains the long-term rate of interest in terms of income, high-powered money, expected rate of inflation, change in the interest rate and the U.S. interest rate. The expected rate of inflation was represented by a polynomially distributed lag on the current and past rates of inflation. Different degrees of polynomials and lengths of lag were tried. A sixteen quarter lag and third degree polynomial were finally selected on the basis of R^2 and the lag structure. Price expectations were found to have a positive and significant effect on the nominal interest rates in Canada, though the effect is not as great as expected. The mean lag for the effect of price expectations on the nominal interest rate was found to be less than two years. It was also found that the price expectations effect was larger in the 'sixties than in the 'fifties.

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TABLE OF CONTENTS

	PAGE
Chapter I	INTRODUCTION
	1
Chapter II	SURVEY OF THE LITERATURE
	6
2.1	Theoretical Background
	6
2.2	Empirical Verification
	11
Chapter III	THE MODEL
	28
3.1	Introduction
	28
3.2	Feldstein-Eckstein Model
	31
3.3	A Model for Canada
	38
Chapter IV	EMPIRICAL INVESTIGATION AND RESULTS
	43
4.1	Estimation of the Model
	43
4.2	Experiments with Other Proxies for Price Variable
	61
4.3	Final Equation
	64
4.4	Some Other Experiments
	67
Chapter V	CONCLUSIONS AND IMPLICATIONS
	79
REFERENCES	
	88
APPENDIX	DESCRIPTION AND SOURCES OF DATA
	94

LIST OF TABLES

	PAGE
TABLE I Summary statistics for the model without adjustment for serial correlation	50
TABLE II Summary statistics for the model after Cochrane-Orcutt transfor- mation	56

LIST OF FIGURES

	PAGE
Figure 1 Distributed lag for (3,16) for the period 1953:1 to 1968:4	59
Figure 2 Distributed lag for (2,24) for the period 1953:1 to 1968:4	62
Figure 3 Distributed lag for (3,16) for the period 1951:1 to 1968:4	66

CHAPTER I

INTRODUCTION

The relationship between nominal interest rates and the expected rate of inflation has attracted a great deal of attention in recent years. The notion of a positive relationship between inflation and interest is, however, not a new one. Rather, it dates back as far as 1740 in a pamphlet by an anonymous author.¹ He wrote "If Bills were to depreciate after a certain Rate, Justice might be done to both contracting Parties, by imposing the Loss which the Principal may sustain in any certain Space of Time (the Period of Payment), upon the Interest of a Bond or Price of Goods: but as Depreciations are uncertain, great Confusions in Dealings happen." [17] John Stuart Mill [40], Jacob de Haas [15], and John B. Clark [13] also expressed the same view subsequently. As Irving Fisher has pointed out, "A principle which apparently has been independently discovered by each of these economic students and quite possibly by others, is likely to be of some importance." [22, p. 357] It was Fisher who in 1896 explicitly formulated the relationship between interest and inflation in a quantitative form [21] and later [22, 23] tried an empirical verification of the relationship. Since then, the effect of

¹ Now identified as William Douglass.

price expectations on nominal interest rates has often been called "The Fisher Effect."

In spite of Fisher's theoretical arguments and the empirical results on the subject, the role of inflation was subsequently ignored in the discussions on interest rates. One of the reasons for this may be the influence of Keynesian theory in which the price level is assumed to remain constant. The neglect of the price expectations effect on interest rates may have been due also to the comparative static mode of analysis adopted by both Keynesians and non-Keynesians, in which "it is possible to consider changes in the equilibrium price level but not a continuous process of inflation." [20, p. 365]. Also, during 'thirties and 'forties, monetary theory tended to decline in importance and monetary policy came to be considered as a relatively ineffective instrument. This may have had something to do with the neglect of the subject during this period.

In recent years, however, much empirical work has been done on the subject. The decline in the importance of monetary theory and policy proved to be a passing phase. "With inflation rather than deflation the issue of the day, the view developed that some flexibility should be restored to monetary policy. Partly as cause and partly as effect, there was a concurrent restoration of interest in monetary theory and many questions which had been thought to be either settled or uninteresting were reopened." [52, p. 312]

Whether there exists a positive relationship between nominal interest rates and price expectations is one such question which seems to have been revived with the revival of interest in monetary theory and policy.

The relationship between nominal interest rates and price expectations is of interest also because it has some bearing on some of the controversial issues in the monetary field. For example, there is, at present, a controversy over the advantages and disadvantages of using interest rates as opposed to using one of the monetary aggregates as an indicator and target for the monetary policy. If the positive relationship between nominal interest rates and the expected rate of inflation is true, it would have implications for the use of interest rates as an indicator of monetary policy. High and rising interest rates are customarily associated with tight money. This association seems to follow from the Keynesian model in which an increase in the money supply will lower the interest rates. However, although a rapid growth in money supply may lower the interest rates temporarily, they would soon foster greater inflation.¹ A rapid expansion in money supply

¹ "There is an impressive body of evidence of long standing, perhaps the most fully established empirical association in all of economics, that there is an association between large scale and rapid changes in the stock of money and changes in the price level." [38, pp. 15-16]

would thus eventually increase (through rising prices leading to an increase in the expected rate of change of prices) rather than decrease the market interest rates if the Fisher Effect operates. Higher (nominal) interest rates may, therefore, actually indicate monetary ease (as measured by the rapid expansion in money supply) rather than restraint.

The increased research effort on the "Fisher Effect" in recent years may have also been due to the fact that the subject provides some scope for the application of expanding econometric techniques for testing hypotheses and for the use of new and sophisticated kinds of lag structures which are both flexible and easy to estimate.

Most of the empirical studies on the subject are based on the United States data. However, these seem to have influenced the thinking on the subject in Canadian financial¹ and economic circles [14, 27] too in the last year or two. Even the Governor of the Bank of Canada seems to accept the price expectations effect now; "the central bank could, by undertaking a rapid monetary expansion, cause some temporary reduction in short-term rates but this

¹ This can be seen in statements such as "Fresh Inflation Fears Will Hike Interest Rates" in The Financial Post (September 18, 1971., p. 26) by John P.S. Mackenzie, Vice-president, Canada Permanent Trust Co.

would increase inflationary expectations and indeed bring about a situation that was in fact more inflationary, so that the longer term result would almost certainly be a higher rather than a lower level of interest rates." [46, p. 13].

However, although the relationship between the nominal rate of interest and price expectations seems to be increasingly accepted in the financial and economic circles in Canada, the existence of price expectations effect has yet to be demonstrated for Canada. There has been just one very recent study for Canada by J. Carr and L. B. Smith [10] which has considered the Fisher Effect. We hold that the results of the study are biased since they are based on an incomplete model of interest rate determination.

The purpose of this study is to verify empirically the positive relationship between the nominal interest rates and inflationary expectations for Canada. In Chapter II, some theoretical and empirical work on "The Fisher Effect" is surveyed. Chapter III describes the Feldstein-Eckstein model for the United States on which our own model for Canada is based. Then, our version of the model is presented. Empirical verification of the model and the results are subsequently presented in Chapter IV. Results of some experiments with the basic model are also given. Chapter V gives the conclusions of the study. Some of the policy and theoretical implications of the study are also noted.

CHAPTER II

SURVEY OF THE LITERATURE

2.1 Theoretical Background

The relationship between the expected rate of change in prices and the nominal interest rate was explicitly formulated by Irving Fisher. He noted that price inflation during the period of the loan depreciates the real value of the principal and interest of bonds and hence results in a capital loss for lenders. This capital loss can be avoided by exchanging money for real capital goods because nominal values of capital goods would rise as prices in general rise. In so far as lenders anticipate changes in the purchasing power of money, they will be willing to lend money only if they receive a yield sufficient to compensate for the loss in the real value of principal and interest. A fall in the real value of borrower's liabilities, as a result of inflation, similarly results in a capital gain for them. Hence, if they expect prices to rise, they will be willing to pay a higher interest. Thus, insofar as lenders and borrowers anticipate changes in the purchasing power of money, bond yields tend to move in the same direction as those changes, which helps preserving the real value of the principal and interest of bonds.

The Fisher Effect can be summarized by the equation

$$R = I + A$$

where R is the nominal rate of interest, I the real rate of

interest and A is the expected rate of inflation.

The equation is based on Fisher's formula connecting the rates of interest in two divergent standards [22] which is derived in the following way. Let wheat fall in gold price (or gold rise in wheat price) so that the quantity of gold which would buy one bushel of wheat at the beginning of the year will buy $1 + a$ bushels at the end; a is therefore the rate of appreciation of gold in terms of wheat. Let the rate of interest in gold be i , and in wheat be r , and the principal of the loan be D dollars or its equivalent B bushels.

The alternative contracts are then:

For every D dollars borrowed, $D + Di$ or $D(1 + i)$ dollars are due in 1 year.

For every B bushels borrowed, $B + Br$ or $B(1 + r)$ bushels are due in 1 year.

The problem is to find the relation between i and r , which makes $D(1 + i)$ dollars equal to $B(1 + r)$ bushels.

Initially, D dollars = B bushels.

At the end of the year, D dollars = $B(1 + a)$ bushels.

Therefore, at the end of the year, $D(1 + i)$ dollars = $B(1 + a)(1 + i)$ bushels.

$D(1 + i)$ dollars or its equivalent $B(1 + a)(1 + i)$ is the number of bushels necessary to liquidate the debt. But the necessary number of bushels to liquidate the debt has already been designated as $B(1 + r)$.

Therefore $B(1 + r) = B(1 + a)(1 + i)$

or $1 + r = (1 + a)(1 + i)$

or $r = i + a + ia$

i.e., "the rate of interest in the relatively depreciating standard is equal to the sum of three terms, viz, the rate of interest in the appreciating standard, the rate of appreciation itself, and the product of these two elements."

[22, p. 359] .

The rate of interest in the relatively depreciating standard is r , and i is the rate of interest in the appreciating standard. Since we are interested in the effect of inflation, which means that money is depreciating, we can take for r the rate of interest in terms of money, i.e. R , and for i the real rate of interest, I . Let a' be the rate of inflation. Then we get:

$$R = I + Ia' + a'$$

However, as Fisher himself pointed out, the influence of changes in the purchasing power of money on the nominal rate of interest will differ depending on whether such a change is foreseen or not. If the change is not anticipated, then a change in the purchasing power of money will not greatly affect the nominal rates, and the real rate of interest may fall as a result of inflation, while the nominal rate rises. Therefore ' a ' in Fisher's equation should be interpreted (as he himself did too [22, p. 264]) as 'expected' rather than 'actual' rate of appreciation. Therefore replacing a' by A , the expected rate of infla-

tion, the equation becomes

$$R = I + A + IA$$

Since the term IA is ordinarily small, it is customarily omitted in the discussions of Fisher Effect. Then, $R = I + A$, that is, the nominal interest rate is equal to the real rate of interest plus the expected rate of inflation.

In the 'Treatise' [35], Keynes gave his reasons for rejecting Fisher's explanation of the positive association between interest and prices. He argued that if a rise in the anticipated rate of inflation reduced bond prices in the way Fisher's arguments imply, investors who hold bonds would be worse off both because they had suffered a capital loss and because their money would be worth less in the future. The capital loss would lead to a fall in nominal holding period yields rather than a rise which Fisher's argument implies. As Sargent [48] has pointed out, this Keynes' contention is based on a confusion between *ex ante* and *ex post* holding period yields. Hayek [31], when reviewing 'Treatise', criticized Keynes on this point. Mrs. Robinson [47] considers Keynes' argument extremely obscure. According to her, "an expectation of falling prices makes fixed interest bonds attractive to rentiers (as opposed to shares and real property), while it makes entrepreneurs prefer short-term borrowing from banks, so that the demand for bonds is high relative to the quantity on offer, and

the bond rate of interest tends to be lower than when prices are expected to be rising." [47, p. 279].

The Radcliffe Committee also advanced the view that price expectations play a distinctive role in the determination of long-term interest rates. "In so far as people foresee a steady rise of prices of 2 percent per annum, they will look for a 5 percent rate of interest instead of 3 percent. Since there are alternative securities, especially equities, which can be expected to increase in money value if inflation continues, bond holders will tend to switch from bonds to equities unless a rise in bond yields offers satisfactory compensation for the expected fall in the real value of the fixed money interest earned on the bonds. There is no doubt at all that this has been a real force in the course of security markets during the post-war period." [43]

This view was challenged by C. Kennedy [34] who argued that a rise in the expected rate of inflation will not lead to a rise in bond rates, but to a fall in the yield on equities. Kennedy's argument was in turn challenged by R. J. Ball [4] who suggested that a rise in the expected rate of inflation would generally lead to some fall in equity yields and some rise in bond yields.

Robert Mundell [41] has subsequently attempted to show that the money rate of interest rises by less than the rate of inflation and thus the real rate falls during

inflation. This conclusion is based on the assumption that real investment depends on the real interest rate and real savings on real balances. Inflation reduces real money balances. The resulting decline in wealth stimulates increased saving, reducing the real rate of interest.

2.2 Empirical Verification

Fisher used British and U.S. data to test his hypothesis [23]. Correlating the actual rate of price change per annum with nominal interest rates, he found that no direct and consistent relation exists between them. He then assumed that the influence of the rate of inflation is distributed in time. More specifically, he assumed that the expected rate of change of prices is a weighted average of current and past rates of inflation. Weights were assumed to decline arithmetically as one goes backward in time. He tried several periods of influence range (that is, the time interval over which the entire effect of a price change would be reflected in a nominal interest rate series) which determines the number of rates of price changes that enter into the weighted average. He then observed which of these weighted averages of past price changes correlated best with the nominal interest rates. The best fit would be obtained where the correlation was highest. This was done for Great Britain for the period 1820-1924 and subperiods; and for the United States for the period 1866-1927 and subperiods. The price variable used was the

wholesale price index.

On the basis of his empirical work, Fisher found that
 (a) interest rate movements lag behind price changes and
 (b) there is a marked correlation between interest rates
 and a weighted average of past price level changes, reflecting effects which are distributed over time.

Fisher's work, however, raises some doubts. The lag implicit in the results of his correlations is distributed over decades. For Great Britain, for 1898-1924, the highest correlation was reached when the effect of price changes on long-term rates was assumed to be spread over 28 years, or a mean lag¹ of 9.3 years. For the United States, the highest correlation was for a distribution of the influence of price changes over 20 years or a mean lag of 7.3 years. The highest correlation between the commercial paper rate and rates of change in wholesale prices for U.S. for 1915 to 1927 was obtained when the latter was lagged over 120 quarters, implying a mean lag of about ten years. Such long lags seem rather implausible. Cri-

¹ Mean lag is a summary statistic for comparing several distributed lag schemes. It is simply a weighted-average lag. For example, for the equation $R = \sum_{j=0}^n W_j P_{t-j} + I$, where P is the actual rate of inflation, the mean lag is given as

$$\frac{\sum_{j=0}^n j W_j}{\sum_{j=0}^n W_j}$$

ticizing the long lags implicit in Fisher's results, Philip Cagan wrote, "Fisher invariably displayed ingenuity in his empirical work but, to this reader's annoyance, he apparently did not consider the overall plausibility of his results." [9, p. 257].

Several other questions can be raised concerning Fisher's empirical results. The assumption that the distributed lag weights decline arithmetically may be too restrictive. Also, his results are based on simple regression techniques. As Sargent has pointed out, "A more compelling body of evidence could be assembled using partial regression methods which allow the investigator to examine the relationship between the expected price change variable and the nominal rate while in some way holding constant the other monetary and real variables which affect the level of the nominal rate." [48, p. 129].

In recent years, there has been a considerable revival of interest in the study of Fisher effects and economists have begun to reassess the impact of price level changes on interest rates. Most of these studies, however, relate to the United States data.

Studies by Suraj B. Gupta [29] and Philip Cagan [9] have attempted to measure 'real' rates directly and then to relate the spread between nominal rates and estimated 'real' rates to historical time series for price level changes. The results, however, were inconclusive.

Most of the other studies have regressed nominal rates directly on current and past rates of price changes, or have regressed change in interest rate on price accelerations. A few have tried to include other variables which may have affected interest rates in addition to price changes. Data intervals in studies of Fisher effects have ranged from monthly [51] to business cycle phases [26]. The time span has ranged from as early as 1869 [28] to as late as 1969 [20, 51]. Proxies for price variable used have been consumer price index, wholesale price index, net national product deflator, gross national product deflator, price deflator for the consumer expenditure component of gross national product and even nominal income. Forms of distributed lags were earlier usually unconstrained lags or geometrically distributed (Koyck) lags and more recently polynomially distributed or Almon lags. Most of the studies have found very long mean lags--ranging from seven to thirty years. However, some very recent studies have found very short mean lags of one to two years.

Meiselman [37] made some preliminary tests of Fisher's hypothesis using Ordinary Least Squares by applying Koyck's lag scheme to U.S. data for 1873-1960 and subperiods. The price variable used was wholesale price index. His results do not unambiguously support Fisher's hypothesis. Yohe and Karnosky [51] calculated the mean lag for Meiselman's study and found a long mean lag--about 20 years. Sargent [48] has criticized the results as being incomplete since

Meiselman did not report results for more flexible forms of Fisher's equation.

Gibson's [28] recent study on 'Price Expectations Effects on Interest Rates' for U.S. data over 1869-1965 used unconstrained lags. Using annual data, when nominal rates were regressed on 5 lagged rates of price change (using the price deflator for net national product as the price variable) there was very little evidence of price expectations effects. Coefficients were often negative. However, when nominal interest rate changes were regressed on current price acceleration and past ten years price accelerations, coefficients were positive, sometimes significant for short-term rates but insignificant for long term rates. It was found that the expectations effect is spread over a longer period, the longer the term of the rate. Quarterly estimates gave roughly the same results.

Sargent [48] recognized that in order to correctly estimate the effect of price expectations on the nominal interest rate, other variables affecting interest rates should also be included in the model. He analyzed the effects of price changes on nominal rates within the framework of a simple loanable funds model. He decomposed the 'real' rate into two components, (a) the equilibrium real rate and (b) the deviation of market real rate from equilibrium rate. He devised the following identity

$$r_{n_t} = r_{e_t} + (r_{m_t} - r_{e_t}) + (r_{n_t} - r_{m_t})$$

rn_t is the nominal interest rate; rm_t is the current market level of real rate; re_t is the rate at which real savings and real investment would be in long run equilibrium.

Taking savings as a function of rm_t and income, investment as a function of rm_t and of change in income, re was derived to be a function of income and of the change in income. For $rm_t - re_t$, he assumed that this gap arises partly from banking systems increasing and decreasing the money supply. The relative changes in real stock of money was assumed to affect the spread between rm_t and re_t . The gap between rn_t and rm_t was assumed to arise as a result of price expectations. Therefore, the nominal rate of interest was assumed to be a function of real income, the change in real income, the relative change in the real stock of money, and a distributed lag on current and past rates of inflation. For empirical estimation purposes, it was assumed that the relationship is a linear one. Lag weights were constrained to decline geometrically.

Using annual data for U.S. for 1902-40 (2 regressions were also run for 1902-54), taking the commodity price index for the price variable, and using Durand's one year and ten year basic yield, he obtained estimates implying very long mean lags. Sargent had cited Cagan's criticism of the long lags implicit in Fisher's results. However, he himself got results which gave even longer lags.

Feldstein and Eckstein [20] have calculated the mean lags implied in Sargents results. The estimated mean lag was 23 years when the period of estimation was 1902-40, and 46 years when the period of estimation was 1902-1954. Such long lags seem absurd.

A one percent permanent increase in inflation rate was estimated to raise interest rates by 1.29 percent with 1902-40 data, 2.47 percent with 1902-54 data, and 6.21 percent with 1902-40 data but with a more general distributed lag structure. According to Feldstein and Eckstein, the reason that Sargent got such implausible coefficients is that he did not treat liquidity explicitly.¹

Yohe and Karnosky [51] in their study of "Interest Rates and Price Level Changes, 1952-69," focused exclusively on the change in anticipated inflation as the only systematic influence on Moody Aaa's bond rate. Using monthly

¹ However when Yohe and Karnosky re-estimated Sargent's equation with quarterly and monthly data over the period 1961-69 with Almon lag structure, the mean lags and the lag weights were reasonable. Sum of the lag coefficients was 0.86, R^2 was 0.977 and the mean lag was 5.5 quarters. So the reason for the implausible coefficients and mean lags in Sargent's study may lie in a different kind of lag structure and a different data set rather than in the "omission of the key liquidity variable."

data, when interest rates were regressed on current and lagged price changes (for 24, 36 and 48 month lag) about 50 percent of the variation in interest rate could be accounted for by price movements. Results using seasonally adjusted data gave results quite close to those using unadjusted data. Coefficients were generally declining. They were small and insignificant for price changes beyond 24 months.

In order to reduce multicollinearity, they then re-estimated the relationship using the Almon lag [1] technique. Regression generated by using a sixth degree polynomial was chosen since it best approximated the unconstrained estimates. Most of the effect on interest rates came from price movements over the previous year. The regression using 48 lags suggested that if the annual rate of change of the consumer price index increased by one percent in a given month and prices continued to rise at that rate, long-term rates would rise 59 basis points (for example, from 4 percent to 4.59 percent) during the first twelve months. After 48 months, there would be a total increase of 56 basis points.

The results of Yohe and Karnosky study are different from those of the earlier studies in yielding very short mean lags of less than a year for both long-term and short-term rates in contrast to mean lags of seven to thirty years found in earlier studies. They investigated the

reasons for this contrast. They found that the lags (usually Koyck lags) estimated in other studies are biased towards yielding longer average lags. This would partly account for the difference in results. Another reason could be that price level changes have come to have larger and prompter effects on interest rates because of institutional changes. To test this, various Almon lag structures were estimated separately for 1952-60 and 1961-69. It was found that the total price expectations effect is much larger in 1961-69 than in 1952-60 period. R^2 for 1961-69 for long-term rates was 0.973 as compared to 0.164 for the earlier period. The sum of the co-efficients was 0.202 in the earlier period and 0.832 in the later one. A mean lag of 16 months was implied for 1961-69. Thus it was concluded that price changes had a greater effect on interest rates in 1960's than in 1950's.

One weakness in Yohe and Karnosky results is that other variables affecting interest rates were not included in the regression so that the regression co-efficients may be biased. However, they did later include other variables given by Sargent's specification, but found that loanable funds variables did not improve the explanatory power of their model. The mean lag, however, increased from 3.2 quarters to 5.5 quarters. The importance of price level changes in explaining nominal interest rates was diluted very little by the expanded equation.

Sargent's work was further explored by L. C. Andersen and K. M. Carlson [2] in their "Monetarist Model for Economic Stabilization." The interest rate was assumed to depend on the current and past rates of change of output, the current rate of change in money stock, and current and past rates of change in prices adjusted by the unemployment rate. The measure of price anticipations used by them will therefore be less for a given inflation rate accompanied by high or rising unemployment than when unemployment is low or is falling. The rationale given by them is that since price changes tend to lag changes in total spending, the degree of resource utilization as measured by the unemployment rate is used as a leading indicator of future price movements. Estimated interest rate equations also contained a dummy variable (0 for 1955-60 and 1 for 1961-69) to indicate a shift in structure in the sample period. The equation was estimated for quarterly data over 1955-69 data with constraints second degree polynomial and right-hand zero restriction. Changes in output and prices (adjusted for unemployment) lagged for 17 quarters gave the most satisfactory results. R^2 was 0.92. Sum of lag coefficients for annual rates of change in GNP deflator (adjusted by unemployment rate) was 0.96. Durbin-Watson statistic was, however, 0.69 indicating the presence of serial correlation in disturbances. Nothing was done to correct this.

S. B. Gupta [30] has recently proposed the following test of the equality between the nominal rate of interest (R) and the sum of the real rate of interest (I) and the expected rate of change of prices (A). If in an appropriately specified demand function for money, R is found to be statistically significant, then almost identical results should follow when the cost of holding money is measured by $I + A$ instead of by R, if the above equality holds.

Gupta has used annual observations for the period 1871-1960 for the United States. Taking for R the average yield to maturity on highest grade long-term bonds, and for I the average expected rate of return on corporate equities, he computed $A = R - I$. The demand for money (currency plus demand deposits) was assumed to be a function of R and of permanent income Y_p .

The two alternative equations were then

$$\log M = \log a_0 + a_1 \log Y_p + a_2 R + e,$$

and
$$\log M = \log b_0 + b_1 \log Y_p + b_2 I + b_3 A + \epsilon$$

He tested the hypothesis that

$$a_2 = b_2 = b_3$$

$$a_1 = b_1 \text{ and } a_0 = b_0$$

Equations were estimated for 1871-60 and various sub-periods. Testing for the equality of co-efficients, he found that movements of R can be represented by movements in $I + A$.

For the United Kingdom, R. J. Ball [5] has investigated

the effect of expected rate of price change on the nominal interest rate. In his "Econometric Analysis of the Long-Term Rate of Interest in United Kingdom, 1921-61", he found that the long-term interest rate can be explained by a model that incorporates Bank rate, money-income ratio and expectations about the future rate or the concept of normal or permanent rate of interest. When Ball attempted to modify the model by incorporating expected rate of change of prices, only the quantity of money relative to income (based on Keynesian liquidity preference function) was included with the price variables. The price variable was represented by the wholesale price index.

Two alternative formulations of price expectations were tried. Expected rate of inflation was defined by a notion of a normal or permanent rate of price increase, i.e.

$$g_t^{eP} = \sum_{i=0}^{\infty} \lambda^{i+1} g_{t-1}^P \quad 0 < \lambda < 1$$

Where g_t^{eP} is the expected and g_t^P the actual rate of price increase. Alternatively the expectational function was given as $g_t^{eP} = g_t^P + \rho(g_t^P - g_{t-1}^P)$ with $\rho < 0$

The effects of including the actual rate of price increase or either of the two alternative measures of price expectations were inconclusive, and price expectations were not found to play a significant role in determining the long term interest rate.

Ball suggests that the patterns of behaviour of

financial institutions in United Kingdom that play a major role in gilt edged market may have in past acted as a buffer between the expected rise in prices and the general level of bond rates. There is a wide class of financial institutions whose primary objective is to maintain an appropriate relation between assets and liabilities in money terms. For example, commercial banks in U. K., as compared to those in U.S., have generally pursued relatively conservative policies with regard to their assets and are not large holders of equities or real estate. Price expectations changes do not therefore materially alter the banks' demand for gilt edged stock. However, Ball points out that as institutions slowly change their investment policies, it may be important to control the rate of inflation to prevent rates from rising further.

There is only one study which has investigated the relation between price expectations and nominal rates of interest for Canadian data. This is by J. Carr and L. B. Smith [10]. The main purpose of their study, however, was to examine the effects of the changes in money supply on the nominal rates. They distinguish between two main channels for the transmission of this effect, one associated with Irving Fisher and the other with Knut Wicksell.

According to Carr and Smith, Fisher's hypothesis begins with the equality of nominal rate of interest to the real rate of interest plus the expected rate of inflation "and

(Fisher) argues that the rate of growth of the money supply affects the expected rate of inflation by affecting the actual rate of inflation." [10, p. 3]. This effect, they argue, takes time to become operative.

Changes in the money supply also have a 'temporary' affect on the real interest rates. Wicksell's model is based on the demand and supply of real loanable funds. The natural (real) rate of interest equates desired savings and desired investment. When the money supply is increased (and prices have not yet adjusted), the total real supply of loanable funds is increased temporarily, causing the market (real) rate to fall below the natural rate.

The Wicksell Effect was represented in Sargent's model by the percentage change in the real money stock. Carr and Smith instead use the difference between the actual and the expected rate of change in money supply to represent this effect. They argue that "unexpected" changes in the rate of growth of the money supply will not be immediately reflected in the price level and will thus change real cash balances initially.

Expected inflation was assumed to be a weighted average of the actual annual rates of inflation in the current and past quarters. Price variable used was the implicit price deflator for GNP. For interest rate they took the average interest yield on long-term Government of Canada

bonds, average interest yield on zero to three year Government of Canada bonds, and the 90 day Government of Canada Treasury Bill Yield. Quarterly data was used.

To estimate the weights for the rates of change in GNP deflator, the Almon Interpolation technique was used. Experimentation with different degrees of polynomial indicated that a second degree polynomial was the most satisfactory. Selection of the length of lag was made on the basis of how closely the sum of weights came to one. For the long-term rate a 24 quarter lag worked the best, while for the shorter rates a 16 quarter lag was chosen. Estimates over the period 1958-69 for the long-term rate, and over 1957-69 for the shorter rates were presented.

Their results show that price expectations play an important role in the determination of nominal rates. The weights were always significant; they first increased and then decreased gradually. The average lag for variations in prices to be transmitted to nominal interest rates was about 11 quarters for long-term bonds, 7 quarters for zero to three year bonds and about 6 quarters for treasury bills. Sum of the weights was about one in the equations they chose to present.

Their model is, however, not a complete model of interest rate determination. Carr and Smith admit that they have considered the effects of monetary variables only on

the nominal rate.¹ Other variables affecting the interest rate are not included in the regression. Hence, the coefficients of price and money variables may capture the effect of the omitted variables also on interest rates. Results may thus be biased.

¹ They have, however, ignored another possible channel through which changes in money supply can affect interest rates besides through Wicksell Effect and Fisher Effect. Changes in money supply may affect the nominal rate also through changes in the nominal and real income. The Friedman-Meiselman study for the Commission on Money and Credit provides evidence of a close relation between money and income in the U.S. over a long period as well as for subperiods. [25]. According to Friedman "changes in M are a major factor, though even then not the only factor, accounting for short-run changes in both nominal income and the real level of activity (y)." [24, p. 217]. Changes in income may, in turn, affect the interest rates through producing changes in savings and/or in investment (or, in terms of liquidity--preference analysis, through increasing the demand for real cash balances.)

Feldstein and Eckstein [20] have investigated the price expectations effect on long-term rates for U.S. in a model which appears to be a more complete model of interest rate determination. Our model for Canada is based on this particular model. Both these models will be discussed in the next chapter.

CHAPTER III

THE MODEL

3.1 Introduction

The purpose of this study is to investigate the relationship between the expected rate of change in prices and nominal interest rates. However, a model of the interest rate which has only the variables representing the expected rate of inflation as the explanatory variables would be a misspecified model. The use of Ordinary Least Squares, when some variables are left out, may introduce bias into the estimates. The bias which originates in this way is called 'Specification Bias'.¹ Therefore, in order to correctly estimate the relationship between nominal interest rates and the expected rate of inflation, other monetary and real variables affecting the interest rates should also be included as independent explanatory variables. In this case, multiple regression analysis will determine the effect of the expected rate of change of prices on the interest rate while keeping constant the other variables which are included in the equation.

¹ The bias depends on two terms 1) the regression coefficient of the left out variable in the true relation, 2) the comovements of the left out variable with the included variables. [42]

In this study of the relationship between nominal interest rates and price expectations, we have chosen the 'long-term' interest rate to represent 'the' interest rate. However, the conclusions following from the study may also apply to the relationship between shorter term rates and price expectations. All the studies¹ which have investigated the effect of price expectations on interest rates on securities of different maturities have found that the long-term rates are relatively less responsive to changes

¹ The study for Canada by Carr and Smith shows an almost equal effect of price expectations on the three month treasury bill yield, the average yield on zero to three year Government of Canada bonds, and average interest yield on long-term Government of Canada bonds, for the equations they finally selected. However, in case of the long-term rate the equal effect is spread over a longer period. For the same length of lag and the degree of polynomial, the sum of the lag coefficients of annual rates of inflation was always higher for short-term rates than for long-term rates. For example, in the case of 32 quarter lag and second degree polynomial, the sum of lag coefficients was 1.64 for the treasury bill yield as compared to 1.35 for the long-term rate.

in price expectations than the short-term rates. According to Gibson's study, a one percentage point increase in the rate of price change raises short-term rates by a third of a percentage point in the following 10 years, while it raises long-term rates by a sixteenth of a point only. Yohe and Karnosky also found the long-term rates to be relatively less responsive to changes in price expectations. Twelve months after the one percent increase in prices, long-term rates would be 59 basis points higher than they were originally, as opposed to 72 basis points for short-term rates. These studies are, no doubt, based on misspecified models. However, studies based on more complete models of interest rate also report similar results. Sargent found greater effect of price expectations on shorter-term rates as compared to long-term rates. Andersen and Carlson found that a permanent one percent increase in the rate of change of prices (adjusted by the index of unemployment rate) would raise the long-term interest rate by 0.96 percent in 16 quarters, while it would raise the short-term rate by 1.27 percent in 10 quarters. If it is true that the long-term rates are relatively less responsive to price expectations than the short-term rates, and if we can establish that price expectations have a positive and significant effect on long-term rates, then it would follow that they affect short-term rates at least as much or to a larger degree. However, we shall be mainly concerned with investigating

the relationship between the 'long-term' rate and price expectations in this study.

3.2 Feldstein-Eckstein Model

The Feldstein-Eckstein model of the determination of the long-term rate of interest for U.S. takes into account factors other than the expected rate of inflation and seems to be a more completely specified model of interest rate than the other models which have considered the relationship between interest rates and the price expectations.

The Feldstein-Eckstein model explains the long-term interest rate in terms of four types of variables: liquidity preference, inflation, government debt and short run expectations. Since our model for Canada includes most of these variables, we shall, in the following pages, discuss the variables in Feldstein-Eckstein model and their theoretical background, often in more detail than they did.

The model recognizes the important role of liquidity (at least in the short run) in the explanation of the long-term interest rate. According to Keynes, [36, p. 167] the rate of interest "is the price which equilibrates the desire to hold wealth in the form of cash with the available quantity of cash."

Keynes analyzed the motives that lead the private sector (individuals, businessmen, and financial institu-

tions) to hold money. The transactions motive relates to the need for holding cash in order to bridge the gap between receipts and payments. The amount of money required for this purpose might be expected to vary directly with the level of income.

A similar motive, holding money for precautionary purposes, relates to the need to provide for unforeseen contingencies requiring sudden expenditure, for unexpected opportunities of advantageous purchase, and to meet the desire for security. Keynes suggested that the demand for money arising from this motive would also depend largely on the level of income. Since the cash balances for this purpose are quantitatively unimportant, they are usually included with transactions balances.

The demand for money, arising out of these motives, is, however, not unaffected by the interest rate. Since the convenience to be had from holding cash for transactions purposes can be traded off against the return to be had from holding other assets instead, Keynes made the transactions and precautionary demand for money a function of interest rate also, although he did not stress the role of interest rates in this part of his analysis. The works of Tobin [50] and Baumol [6] on transactions demand for money also suggest that the transactions demand is not independent of the interest rate.

The other main motive for holding money is known as

the 'Speculative Motive'. It was defined as 'the object of securing profit from knowing better than the market what the future will bring forth.' Keynes focused on two alternative ways of holding assets--money and long-term bonds. The monetary value of money was fixed. (the price level was assumed to be fixed), but the value of bonds would change with the change in the interest rate. Changes in the interest rate would involve capital gains or losses for bond holders. So investors would consider the prospective capital gains or losses from holding bonds as well as the interest they would receive. If interest rates were very low relative to 'normal' levels, bond prices will be considered to be too high and future capital losses for the bond holders probable. If the capital losses in question are expected to be large enough to more than offset interest earnings, it would be more profitable to hold money even with its zero yield.

For the aggregate economy, given the 'normal' level of interest rate, (which should, strictly speaking, be interpreted as a vector and not as a number) different people have different expectations about the changes in interest rate toward this level. If the money and bond holdings of each individual are an insignificant proportion of the totals for the economy, and if there is some diversity of opinion about the expected rate of change of interest rate, the aggregate speculative demand for money func-

tion becomes a smooth and negative function of the current rate of interest.

Thus, the liquidity preference function or the demand for money function is a relation between the quantity of money, the level of income and the rate of interest. The demand for cash balances is an increasing function of income and a decreasing function of the rate of interest. Most of the empirical studies have analyzed the liquidity preference theory by estimating a demand for money function [7, 8, 39]. However, if the money supply is taken to be exogenously given, then since the demand for money must equal the supply *ex post*, the liquidity preference function determines the interest rate. It defines the bond interest rate at which investors are content to hold the available supply of money. Given the income level, an increase in the money supply will lower the interest rate. An increase in income will shift the demand curve for money to the right and, given the money supply, raise the interest rate.

Feldstein and Eckstein defined the liquidity variable as the exogenous high powered money¹ which equals the cash

¹ The determinants of the stock of money (defined as currency outside banks plus demand deposits) are (a) the high-powered money, (b) the currency-money ratio, and (c) the reserve ratio. The money stock increases with an

reserves of the Federal Reserve member banks plus the currency held by the non-bank public. These represent the monetary assets of the public that, unlike demand and time deposits, are not also the direct or indirect liabilities of other individuals.

Feldstein and Eckstein represented the expected rate of inflation by the current rate of inflation and a distributed lag on previous 23 quarterly rates. The hypothesis of a distributed lag with weights constrained to satisfy a third degree polynomial was used and the estimation was by the Almon lag technique.

The combination of a liquidity preference model and Fisher's model of anticipated inflation was found to give a very good explanation of the long term interest rate.

$$RC_t = -11.27 - 6.76 \log RMBPC_t + 6.03 \log RPYPC_t + 0.275 \pi_t$$

(0.18) (0.069)

$$+ \sum_{j=1}^{23} a_j \pi_{t-j}$$

$$\sum_{j=1}^{23} a_j = 3.41$$

$$R^2 = 0.982$$

$$D.W. = 1.03$$

$$\text{Mean lag} = 8.14 \text{ quarters}$$

increase in the high-powered money or with a decline in either of the two ratios. According to Philip Cagan [11], nine-tenths of the secular growth of the money stock in U.S. over the period 1875-1955 was accounted for by the expansion of high-powered money. Findings by D. Fand and others

where RC is the average yield to maturity on Moody's Aaa corporate bonds, i.e. high grade bonds that are already several years old and have approximately 25 years to maturity. RMBPC is the real per capita monetary base. Monetary base equals the reserves of Federal Reserve member banks plus currency held by non-bank public with appropriate adjustments for changes in reserve requirements and seasonal variation.

RPYPC is per capita real private gross national product.

The equation is "specified in terms of the logarithms of the liquidity and income variables" implying "the traditional convex liquidity preference function." [20, p. 364] π_t is the quarterly inflation rate defined as

$$\pi_t = \frac{100(P_t - P_{t-1})}{P_{t-1}}$$

where P_t is the price deflator for the consumer expenditure component of G.N.P.

Lag coefficients were found to decline almost linearly. $\sum_{j=0}^{23} a_j = 3.69$ implied that a permanent one percent increase in the annual rate of inflation would raise the interest rate by 0.92 percent, implying that, in the long run, the real rate is almost unaffected by the

[18] show that by controlling the movements in the monetary base, monetary authorities can control quite adequately the movements in the money stock.

rate of inflation. The impact of expected inflation is much larger than in Yohe-Karnosky equations while the mean lag is longer. When Feldstein-Eckstein re-estimated Yohe-Karnosky equations with their data, R^2 was unchanged at 0.52 and there was the same "false rapid response". They concluded that "although inflation has a very important effect on interest rates, its impact can only be estimated appropriately with a model that recognizes the equally important role of liquidity."

Since government debt is a relatively close substitute in portfolios for corporate bonds, the quantity of government debt would be expected to affect the interest rates. An increase in the quantity of government debt that has to be absorbed by the public would be expected to raise the corporate bond interest rate. When Feldstein and Eckstein included the real per capita privately owned federal government debt (RDEBTPC) they found it to have a positive and significant effect on the corporate bond rate.

If investors expect the long-term interest rates to increase in future, they will substitute short-term assets like money and treasury bills for bonds. This reduction in the demand for bonds will reduce their price and hence increase their yield. Feldstein and Eckstein assumed that the expectation of future rates are based on the most recent past history of interest rate changes. When the

expected interest rate change, as measured by the lagged change in the long run rate itself, was included to allow for the effect of anticipated capital gains or losses on the current demand for bonds, the coefficient was positive and significant.

Since the equation involved lagged dependent variables in the presence of serially correlated disturbances an instrumental variable estimation of the type suggested by Livitian was used to re-estimate the equation. The estimated equation was

$$RC_t = -15.21 - 8.48 \log RMBPC_t + 7.59 \log RPYP C_t$$

(0.81) (0.72)

$$+ 2.04 \log RDEBTPC_t + 0.233 \pi_t + \sum_{j=1}^{23} a_j \pi_{t-j}$$

(0.89) (0.061)

$$+ 0.33(RC_{t-1} - RC_{t-2})$$

(0.19)

$$\sum_{j=1}^{23} a_j = 3.82$$

$$R^2 = 0.990$$

$$D.W. = 1.282$$

$$\text{Mean lag} = 8.13 \text{ quarters}$$

3.3 A Model for Canada

Our model for Canada recognizes the important role played by liquidity preference, price expectations and

the short run expectations of changes in interest rates in the determination of interest rates.

Our specification of the model of interest rate determination for Canada also takes into account the openness of the Canadian economy. The sensitivity of long-term capital movements to the differential between Canadian and foreign interest rates has been established for some time.

Foreign investors will buy Canadian securities when they expect a higher return on Canadian relative to other securities. Canadian borrowers will sell securities abroad when they expect that the cost of funds obtained in this way is less than the cost of borrowing from Canadian residents. The return on the investment, or the cost of borrowing, reflects the interest on security, changes in capital value as a result of any expected change in market interest rates and the change in capital value resulting from any expected change in the exchange rate. The net inflow of long-term capital should increase when there is a higher return to Canadian than to foreign securities.

Although there is a net inflow of external funds to Canada from many countries, the predominance of U.S. capital has led most studies relating to capital movements to concentrate on variables relating to U.S.-Canadian flows. Measuring the degree of capital market integration by the responsiveness of capital flows to changes in interest rate differential, Caves and Reuber [11, 12] found that the

financial markets in U.S. and Canada are very closely though not perfectly integrated. Their estimates for the period 1952-61 show that a one percent change in the long-term rate differential evoked a change in the long-term capital flows of roughly 10 percent in the same quarter.

In the Bank of Canada's RDX1 model¹ [32] the main variable explaining the net capital inflows is the interest rate differential between U.S. and Canada. The interest rate differential was tried in both current as well as distributed lag form. The differential and its first difference were tried alternatively. The current interest differential produced equations with the highest explanatory power.

A partial explanation for the observed similarity between Canadian and U.S. rates movements may lie in the interaction between capital flows and interest rates. A rise in the U.S. rate shrinks the Canadian-U.S. interest rate differential causing a large exodus of foreign capital. This would in turn limit the adverse movement of interest rate differential from Canadian point of view.

¹ RDX1 (Research Department "Xperimental" Model - version 1) is "an intermediate sized aggregate quarterly model of the Canadian economy." It is the preliminary result of a larger econometric research program sponsored by the Research Department of the Bank of Canada.

In the explanation of the long-term interest rate in RDX1 Canadian long-term interest rates are related directly to fluctuations in U.S. long-term rates and to changes in Canadian short-term rates. It was found that a one percent increase in the U.S. long-term interest rate raises the Canadian long-term rate by 0.216 percent.

Estimates by Caves and Reuber [11, 12] also indicate the relation between the U.S. and Canadian interest rates. They found that a one percent rise in U.S. rate would raise Canadian Government long-term rate by 18.35 basis points, and thus the net movement of interest rate differential against Canada would be 81.65 basis points. If the McLeod-Weir interest rate series are used, it was found that the independence of Canadian from foreign rates was further reduced. About 20 to 30 percent of any change in U.S. rate was found to be fed into the Canadian rate through the induced changes in capital flows. Estimates by Two Stage Least Squares suggest that up to 60 percent of the changes in U.S. rate may be fed into Canadian rate through the interaction between capital flows and interest rates.

In view of the close relationship between the U.S. and Canadian interest rates, our model includes U.S. long term interest rate also as an explanatory variable.

Therefore, the long-term interest rate in our model depends on the following variables: income, high-powered money, short run expectations, United States long-term

interest rate, and the expected rate of inflation.

CHAPTER IV

EMPIRICAL INVESTIGATION AND RESULTS

4.1 Estimation of the model

The model to be investigated is

$$\begin{aligned} \text{RL} = & A_0 + A_1 Q_1 + A_2 Q_2 + A_3 Q_3 + b \log \text{PCPGNER} \\ & + c \log \text{RPCHPM} + d \text{CHRL} + e \text{USRL} + a_0 \text{INF} \\ & + \sum_{j=1}^{n-1} a_j \text{INF}_{t-j} + \mu \end{aligned}$$

where RL is the long term Government of Canada bond yield average. It is the arithmetic average on all direct Government of Canada bonds denominated in Canadian currency, due or callable in ten years or more.

Q_1 , Q_2 and Q_3 are seasonal dummies. Their value is one in the relevant quarter and zero otherwise.

PCPGNER is per capita private gross national product in constant 1957 dollars (thousands). It is calculated as $(\text{GNER} - \text{GER}) / \text{POP}$ where GNER is the gross national product in constant 1957 dollars (millions) and GER is the government expenditure component of gross national product in constant 1957 dollars (millions). POP is the estimated population of Canada (thousands).

RPCHPM is the real per capita high-powered money (thousands of dollars). It is equal to $(\text{HPM1} +$

HPM2)/(P1 . POP) where HPM1 is the total Canadian cash reserves held by chartered banks and HPM2 is the total currency outside banks (millions of dollars). P1 is the implicit price deflator for gross national product (1957 = 100).

CHRL is $RL_t - RL_{t-1}$ or the current change in the interest rate.

USRL is the long-term government bond yield in the United States.

INF is the quarterly inflation rate, that is

$$\frac{(P_t - P_{t-1})}{P_{t-1}} \quad 100$$

where P_t is the implicit price deflator for the consumer expenditure component of GNP in quarter t .

μ is the error term.

In Canada, because of developed financial markets, different marketable securities are usually regarded as close substitutes for each other. Interest yield on any particular marketable security is also affected by the supply and demand conditions in markets for other securities. Therefore, all interest yields tend to move together. The choice of 'the' interest rate in any particular study, therefore, depends partly on the availability of suitable statistics. For this study the interest rate on Government

rather than on corporate bonds was selected partly because of the easy availability of data on the former covering almost two decades; and partly on the basis of other studies for Canada involving long-term interest rate which have mostly used government rather than corporate bond yields.¹

Both the income and liquidity variables have been converted to real terms. Keynes qualified his theory by assuming that the price level was fixed. Liquidity preference theory is thus a theory of demand for money in real terms. Demand for money in real terms depends on the real income and the real rate of interest.

¹ Officer [42] assumed that the government long-term bond rate is indicative of the spectrum of rates in the entire long-term securities market. According to Caves and Reuber [12], the federal government's yields used by Officer are probably the best proxies for the general state of the capital markets. Carr and Smith [10] have used government bond yields rather than corporate bond yields since in recessionary periods the risk of default in corporate bonds increases, tending to push their yields up.

An increase in income or liquidity, that merely represents a larger population with the same average income or liquidity as before, will presumably have quite different effects on the long-term interest rate than would the same increase in aggregate income and liquidity with a stable population and increasing per capita income and liquidity. Thus, in order to provide a better estimate of the relationship, both income and liquidity variables have been put on a per capita basis.

The equation is specified in terms of logarithms of the income and liquidity variables as it appears reasonable to assume that equal changes in interest rates are more closely related to equal percentage changes in liquidity and income than with equal absolute changes. Also, this particular specification implies the traditional convex liquidity preference function. Formally, we have

$$\frac{\partial RL}{\partial PCPGNER} = \frac{b}{PCPGNER}$$

and

$$\frac{\partial RL}{\partial RPCHPM} = \frac{c}{RPCHPM}$$

that is, the marginal influence of income on interest rates is inversely proportional to the level of income. The same holds for the liquidity variable.

High powered money has not been corrected for changes in reserve requirements. There were changes in reserve

requirements in 1954 and in 1967, which have not been allowed for. However, it is hoped that this will not greatly affect the co-efficients of price changes.

Our choice of the price variable follows Feldstein and Eckstein who have pointed out that "consumer prices are widely cited and therefore likely to be influential in the formation of expectations." [20, p. 365].

For the a_j 's we have used the hypothesis of a polynomially distributed lag structure. If an unconstrained distributed lag function is estimated directly, the presence of too many regressors which may be closely related, would result in the problem of multicollinearity. Ordinary least squares, in this case, would give unbiased estimates, but standard errors are typically very large. In addition, with small changes in specification, we may get wildly fluctuating co-efficients. The problem of multicollinearity can be handled by putting certain restrictions on the lag structure such that the lag structure depends on only a few parameters which can be estimated directly and then working backwards to solve for the individual a_j 's. Of the few methods of doing this, Almon polynomial technique [1] is perhaps the one most widely accepted. It avoids the problem of multicollinearity and results in a smoother distribution. In using this technique one has to specify a degree of polynomial, a length of the lag and whether there is any right hand or left hand zero restric-

tion or not.

It seems reasonable to assume that the current rate of inflation would have an independent effect on interest rates rather than having an effect which is constrained in a particular structure along with past rates of inflation. Therefore, it was decided not to constrain the current rate of inflation in the polynomial lag structure.

Our model focuses attention on a single equation, whereas "the essence of economic theory is the interdependence of economic phenomena and the determination of the values of economic variables by the simultaneous interaction of relationships." [33, p. 146]. As a result of the simultaneous nature of economic relations, some of the explanatory variables in our equation will be correlated with the disturbance term. The application of ordinary least squares method will, in this case, give biased and inconsistent estimates. However, as Johnston has pointed out, "This fact alone will not necessarily rule out the use of ordinary least squares as an estimating method, since the choice of a method in practice has to be made on a balance of the properties of the method and computational simplicity." [33, p. 253]. It was on grounds of simplicity that we estimated our equation using ordinary least squares.¹

¹ All the other studies on 'Fisher Effect' have also used ordinary least squares to estimate the relationship.

Quarterly data over the period 1947:1 to 1968:4 was used. In order to select the appropriate length of the lag and the degree of the polynomial, equations were estimated for degrees of polynomial from one to four, and length of lag from 12 to 24 quarters in steps of 4. In the estimation of equations with different lengths of lag, different number of observations are lost and hence R^2 for these different equations are not strictly comparable in determining the appropriate lag structure. To avoid this problem, experimentation with various combinations of lengths of lag and degrees of polynomial was done over the common data set 1953:1 to 1968:4. A right-hand zero restriction was used in all cases which constrains a_n to be equal to zero.

The co-efficient of multiple determination is denoted as R^2 . It shows the proportion of the total variation in the dependent variable that can be explained by the regression equation. The assumption of independence of regression disturbances is tested by using Durbin-Watson statistic, denoted as D.W.

Results on R^2 , D.W., Mean lag and the sum of co-efficients of current and past rates of inflation are given in Table I.

The results are not altogether satisfactory. Although R^2 is very high--ranging from 0.9658 to 0.9814--the equations did not work very well in terms of the expected signs of coefficients of independent variables and the signs

TABLE I

SUMMARY STATISTICS FOR THE MODEL WITHOUT
ADJUSTMENT FOR SERIAL CORRELATION.

$(m,n)^1$	R^2	D.W.	Mean Lag	$\sum_{j=0}^{n-1} a_j$
(1,12)	0.9675	1.02	3.33	-0.220
(2,12)	0.9693	1.00	0.24	-0.171
(3,12)	0.9756	1.11	-5.56	-0.078
(4,12)	0.9760	1.09	-14.79	-0.050
(1,16)	0.9658	0.91	4.66	0.004
(2,16)	0.9788	1.01	19.64	0.185
(3,16)	0.9806	1.01	18.29	0.202
(4,16)	0.9814	1.05	18.92	0.171
(1,20)	0.9661	0.84	6.00	0.145
(2,20)	0.9751	0.86	15.09	0.352
(3,20)	0.9766	0.95	16.21	0.307
(4,20)	0.9802	1.02	19.47	0.177
(1,24)	0.9670	0.80	7.33	0.320
(2,24)	0.9734	0.89	13.57	0.504
(3,24)	0.9761	0.93	15.50	0.342
(4,24)	0.9762	0.90	15.55	0.332

¹ (m,n) is the equation with degree of polynomial m and the length of lag n (in quarters).

and/or the significance¹ of the current and past rates of inflation. The coefficient of income variable was negative in case of 12 quarter lag and in case of the first degree polynomial for other lengths of lags. It was positive in all other equations though not always significant. The coefficient of the change in interest rate was sometimes positive and sometimes negative but not significant in either case. The coefficient of the U.S. interest rate was positive and highly significant in all cases, confirming that the U.S. interest rate is a very important variable in explaining the Canadian interest rate. The current rate of inflation had a positive but insignificant effect on the long-term interest rate (except for (4,16) where the coefficient was negative). Lag weights were often negative for the first few lagged rates of inflation and then became positive. Seasonal dummies were not significant.

The mean lag ranged from -14.79 to 19.64 quarters and the sum of the weights $\sum_{j=0}^{n-1} a_j$ ranged from -0.220 to 0.504. The average lag and/or the sum of co-efficients of current and past rates of inflation were negative only in the case of twelve quarter lag.

Negative values for $\sum a_j$ are not consistent with our hypothesis. The very small $\sum a_j$ implies that the rate of inflation has a very slight effect on the long-term interest rate. The largest effect is in the case of the equa-

¹ At 5 percent level of significance.

tion with weights of lagged rates of inflation constrained to a second degree polynomial and length of lag equal to 24 quarters. Results for this equation are given below in more detail. t values are given in parentheses.

$$RL = -6.86 - 0.031 Q_1 - 0.08 Q_2 - 0.024 Q_3$$

$$(-3.3) \quad (-0.4) \quad (-1.2) \quad (-0.27)$$

$$+ 0.36 \log PCPGNER - 3.4 \log RPCHPM - 0.11 CHRL$$

$$(0.58) \quad (-2.5) \quad (-0.8)$$

$$+ 1.39 USRL + 0.05 INF + \sum_{j=1}^{23} a_j INF_{t-j}$$

$$(17.27) \quad (1.05)$$

$$\sum_{j=0}^{23} a_j = 0.504$$

$$R^2 = 0.9734$$

$$D.W. = 0.89$$

Mean lag = 13.57 quarters

$$a_1 = -0.019 \quad (-0.91)$$

$$a_{11} = 0.033 \quad (3.13)$$

$$a_2 = -0.011 \quad (-0.57)$$

$$a_{12} = 0.034 \quad (3.33)$$

$$a_3 = -0.003 \quad (-0.18)$$

$$a_{13} = 0.035 \quad (3.49)$$

$$a_4 = +0.004 \quad (0.25)$$

$$a_{14} = 0.035 \quad (3.61)$$

$$a_5 = 0.010 \quad (0.72)$$

$$a_{15} = 0.035 \quad (3.70)$$

$$a_6 = 0.015 \quad (1.21)$$

$$a_{16} = 0.033 \quad (3.77)$$

$$a_7 = 0.020 \quad (1.69)$$

$$a_{17} = 0.032 \quad (3.81)$$

$$a_8 = 0.024 \quad (2.13)$$

$$a_{18} = 0.029 \quad (3.85)$$

$$a_9 = 0.028 \quad (2.53)$$

$$a_{19} = 0.026 \quad (3.87)$$

$$a_{10} = 0.031 \quad (2.86)$$

$$a_{20} = 0.022 \quad (3.89)$$

$$a_{21} = 0.018 \quad (3.90)$$

$$a_{23} = 0.007 \quad (3.91)$$

$$a_{22} = 0.012 \quad (3.90)$$

The highest R^2 (0.9814) is for equation (4,16). For (3,16) the R^2 is only slightly lower (0.9806) but the equation performs better than (4,16) in the sense of having a smaller number of negative lag coefficients and having a positive sign for the coefficients of current rate of inflation. Thus the results for the equation where lag structure is constrained to the third degree polynomial and 16 quarter lag are given below in detail.

$$RL = -6.96 + 0.055 Q_1 - 0.07 Q_2 - 0.086 Q_3$$

$$(-4.44) \quad (0.76) \quad (-1.11) \quad (-1.075)$$

$$+ 1.18 \log PCPGNER - 4.2 \log RPCHPM$$

$$(2.04) \quad (-3.7)$$

$$+ 0.07 CHRL + 1.26 USRL + 0.0005 INF + \sum_{j=1}^{n-1} a_j INF_{t-j}$$

$$(0.55) \quad (16.49) \quad (0.01)$$

$$\sum_{j=0}^{15} a_j = 0.20$$

$$R^2 = 0.9806$$

$$D.W. = 1.01$$

$$\text{Mean lag} = 18.3 \text{ quarters}$$

$$a_1 = -0.062 \quad (-2.3)$$

$$a_4 = -0.025 \quad (-1.9)$$

$$a_2 = -0.052 \quad (-2.7)$$

$$a_5 = -0.010 \quad (-0.8)$$

$$a_3 = -0.039 \quad (-2.6)$$

$$a_6 = 0.005 \quad (0.4)$$

$a_7 = 0.020$ (1.6)	$a_{12} = 0.058$ (5.7)
$a_8 = 0.033$ (2.8)	$a_{13} = 0.053$ (5.7)
$a_9 = 0.044$ (3.9)	$a_{14} = 0.042$ (5.5)
$a_{10} = 0.053$ (4.9)	$a_{15} = 0.025$ (5.3)
$a_{11} = 0.057$ (5.5)	

The small value of D.W. in all the equations implies that there is positive autocorrelation in the disturbances. When error terms are serially correlated, the estimates by ordinary least squares, though unbiased, do not have minimum variance. The estimates may be badly wide of the target.

Therefore, we next proceeded to take into account specifically the autoregressive structure of the error term. It was assumed that error terms are generated by a first order Markov scheme, i.e.

$$u_t = \rho u_{t-1} + e_t$$

where e_t is assumed to be drawn at random from a distribution with mean zero and variance σ_e^2 and is distributed independently of past values of e 's. ρ is the first order autocorrelation coefficient. The Cochrane-Orcutt option in the Princeton regression package was used to take into account this autoregressive structure of disturbances.¹

¹ Princeton University, Department of Economics TSP (360-91) Time series Processor, User's Manual. The Cochrane-Orcutt procedure "uses an ordinary least squares regression to form an initial guess of ρ , the first order

All the equations for second to four degree polynomials were estimated by this method. Results on R^2 , D.W., and mean lag and Σa_j are given in Table II.

Results were highly satisfactory. R^2 ranged from 0.9893 to 0.9928. It was not very different for different lengths of lags and for different degrees of polynomial.¹ Coefficients of explanatory variables generally had the expected signs and were significant.² The only unsatisfactory feature of the results was that D.W. was still quite low, ranging from 1.01 to 1.235, indicating that the positive autocorrelation of the disturbances persisted.

The results showed that as the length of the lag was

serial coefficient. The following iteration then occurs:

- all data are transformed by rho (e.g.: $x_t - \hat{\rho} x_{t-1}$)
- regression is run on transformed data

- the regression coefficients are multiplied into the original dependent variables to recalculate the serially correlated errors

- a new estimate of rho is formed.

When rho changes by less than .005 from one iteration to the next or when 20 iterations have occurred, iteration terminates and regression output is produced." [p. 26]

¹ For any particular length of the lag, however, R^2 showed a small increase with an increase in the degree of polynomial.

² The second and third quarter seasonal dummies were significant and negative.

TABLE II

SUMMARY STATISTICS FOR THE MODEL AFTER
COCHRANE-ORCUTT TRANSFORMATION

(m,n)	R^2	D.W.	Mean Lag	$\sum_{j=0}^{n-1} a_j$
(2,12)	0.9893	1.01	3.53	0.41
(3,12)	0.9905	1.17	4.86	0.44
(4,12)	0.9913	1.24	4.66	0.68
(2,16)	0.9923	1.14	6.69	1.32
(3,16)	0.9927	1.18	6.95	1.22
(4,16)	0.9928	1.22	6.95	1.18
(2,20)	0.9908	1.08	7.30	1.23
(3,20)	0.9911	1.08	6.97	1.31
(4,20)	0.9920	1.19	7.15	1.20
(2,24)	0.9906	1.10	7.98	1.47
(3,24)	0.9909	1.08	7.36	1.40
(4,24)	0.9910	1.09	7.49	1.36

increased, mean lag also increased. Mean lag was, on average, around 4.35 quarters for 12 quarter lag, 7.16 quarters for 20 quarter lag, and 7.61 quarters for 24 quarter lag. Sum of the coefficients of current and lagged rates of inflation also increased as the length of the lag was increased. $\sum_{j=0}^{n-1} a_j$ ranged from 0.41 to 0.68 for 12 quarter lag, 1.20 to 1.31 for 20 quarter lag and from 1.36 to 1.47 for 24 quarter lag. The twelve quarter lag does not seem to be very suitable since its estimates of mean lag and $\sum a_j$ are much smaller than for other lengths of lags; while for other lengths of lags, the results in this respect are not as different from each other.

(4,20), (3,24) and (4,24) give one or two negative coefficients at the tail of the lag distribution. (3,12) and (4,16) give weights which fall, rise and then fall again, while (4,12) gives weights which rise, fall, rise and then fall again. Such patterns are difficult to explain.

(2,12), (2,16), (3,16), (2,20), (3,20) and (2,24) give weights which first rise and then fall. Of these, (3,16) gives highest R^2 . So we have selected the equation where lag weights have been constrained to a third degree polynomial and 16 quarter lag as giving the most appropriate model.

$$RL = -2.99 + 0.02 Q_1 - 0.076 Q_2 - 0.096 Q_3$$

$$(-1.89) \quad (0.63) \quad (-2.56) \quad (-2.39)$$

$$+ 0.94 \log PCPGNER - 3.57 \log RPCHPM$$

$$(2.88) \quad (-4.16)$$

$$+ 0.37 CHRL + 0.52 USRL + 0.0476 INF$$

$$(5.72) \quad (5.50) \quad (1.89)$$

$$+ \sum_{j=1}^{15} a_j INF_{t-j}$$

$$\sum_{j=0}^{15} a_j = 1.22$$

$$R^2 = 0.9927$$

$$D.W. = 1.18$$

$$\text{Mean lag} = 6.95 \text{ quarters}$$

$$\rho = 0.96$$

$$a_1 = 0.053 \quad (1.63)$$

$$a_9 = 0.102 \quad (4.89)$$

$$a_2 = 0.060 \quad (2.26)$$

$$a_{10} = 0.100 \quad (5.07)$$

$$a_3 = 0.067 \quad (2.84)$$

$$a_{11} = 0.096 \quad (5.16)$$

$$a_4 = 0.075 \quad (3.30)$$

$$a_{12} = 0.087 \quad (5.11)$$

$$a_5 = 0.083 \quad (3.66)$$

$$a_{13} = 0.073 \quad (4.99)$$

$$a_6 = 0.090 \quad (3.99)$$

$$a_{14} = 0.055 \quad (4.82)$$

$$a_7 = 0.096 \quad (4.32)$$

$$a_{15} = 0.030 \quad (4.62)$$

$$a_8 = 0.100 \quad (4.63)$$

Figure 1 shows the co-efficients of the lagged rates of inflation for (3,16).

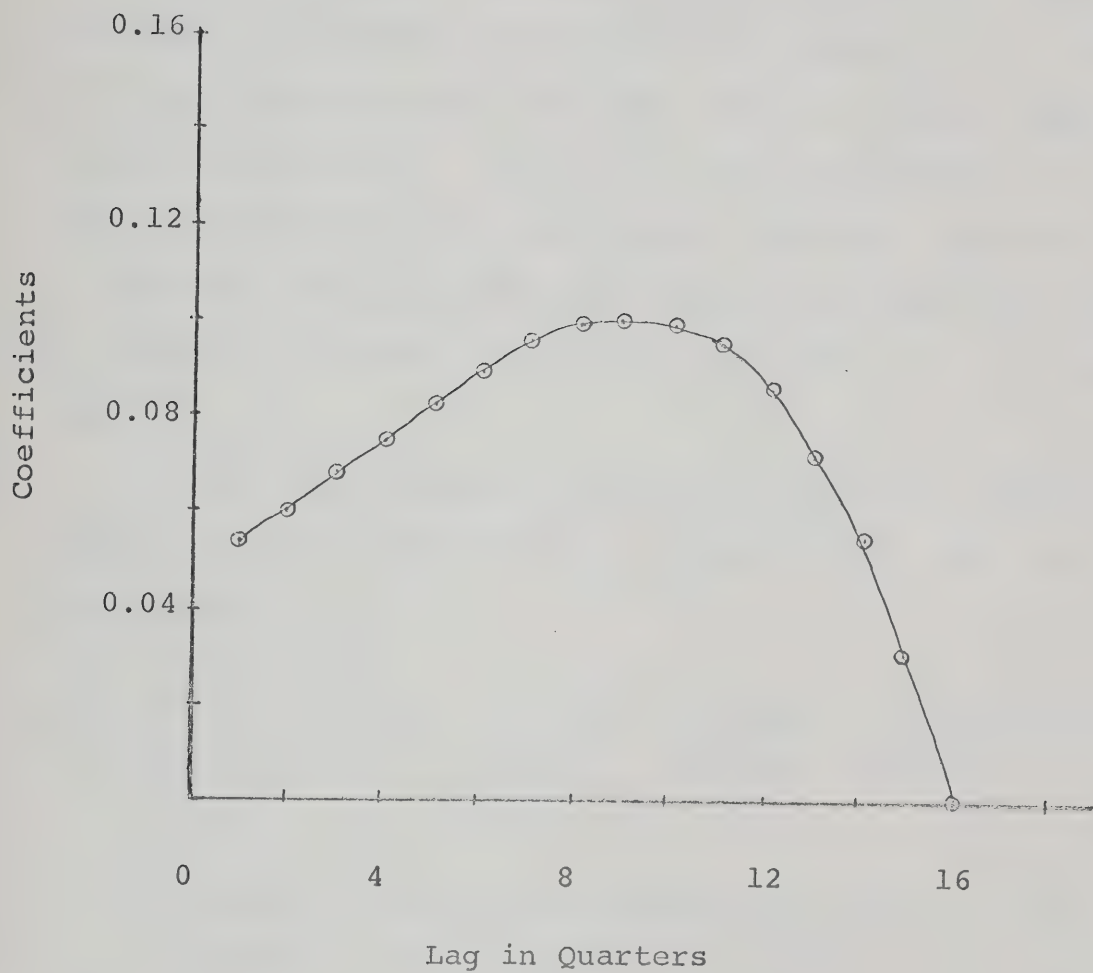


Figure 1

Distributed lag for (3,16) for the
period 1953:1 to 1968:4

The sum of the co-efficients of current and lagged rates of inflation is equal to 1.22, which implies that a permanent one percent increase in the annual rate of inflation would increase the long-term interest rate by approximately 0.305 percent. Almost all the co-efficients of rates of inflation are significant. Thus the expected rate of inflation does significantly affect the long-term rate of interest. However, the effect is not as large as expected.

Results for equation (2,24) which gives the largest effect of rates of inflation on interest rate, are also given below.

$$RL = -3.12 + 0.04 Q_1 - 0.07 Q_2 - 0.12 Q_3 + 1.05 \log PCPGNER$$

$$(-1.75) \quad (1.01) \quad (-2.06) \quad (-2.62) \quad (2.82)$$

$$- 3.33 \log RPCHPM + 0.32 CHRL + 0.61 USRL$$

$$(-3.43) \quad (4.53) \quad (5.99)$$

$$+ 0.08 INF + \sum_{j=1}^{23} a_j INF_{t-j}$$

$$(3.01)$$

$$\sum_{j=0}^{23} a_j = 1.47$$

$$R^2 = 0.9906$$

$$D.W. = 1.105$$

$$\text{Mean lag} = 7.98 \text{ quarters}$$

$$\rho = 0.95$$

$a_1 = 0.098$ (3.07)	$a_{13} = 0.061$ (2.60)
$a_2 = 0.096$ (3.31)	$a_{14} = 0.056$ (2.47)
$a_3 = 0.094$ (3.51)	$a_{15} = 0.052$ (2.34)
$a_4 = 0.091$ (3.64)	$a_{16} = 0.047$ (2.24)
$a_5 = 0.089$ (3.68)	$a_{17} = 0.042$ (2.14)
$a_6 = 0.086$ (3.65)	$a_{18} = 0.036$ (2.05)
$a_7 = 0.083$ (3.55)	$a_{19} = 0.031$ (1.97)
$a_8 = 0.080$ (3.40)	$a_{20} = 0.025$ (1.90)
$a_9 = 0.076$ (3.24)	$a_{21} = 0.019$ (1.83)
$a_{10} = 0.073$ (3.07)	$a_{22} = 0.013$ (1.77)
$a_{11} = 0.069$ (2.90)	$a_{23} = 0.006$ (1.71)
$a_{12} = 0.065$ (2.74)	

The graph of the distributed lag for (2,24) is given in Figure 2.

4.2 Experiments with Other Proxies for Price Variable.

As mentioned before, some other studies on the relation between price expectations and interest rates have chosen the implicit price deflator for gross national product, the consumer price index or the wholesale price index as a proxy for the price variable in calculating the rate of inflation. In order to see whether these proxies for the price variable work empirically better than the measure used by us in our model, the model was re-estimated for (3,16) by the Cochrane-Orcutt method replacing INF in turn by INF 1, INF 2 and INF 3, where

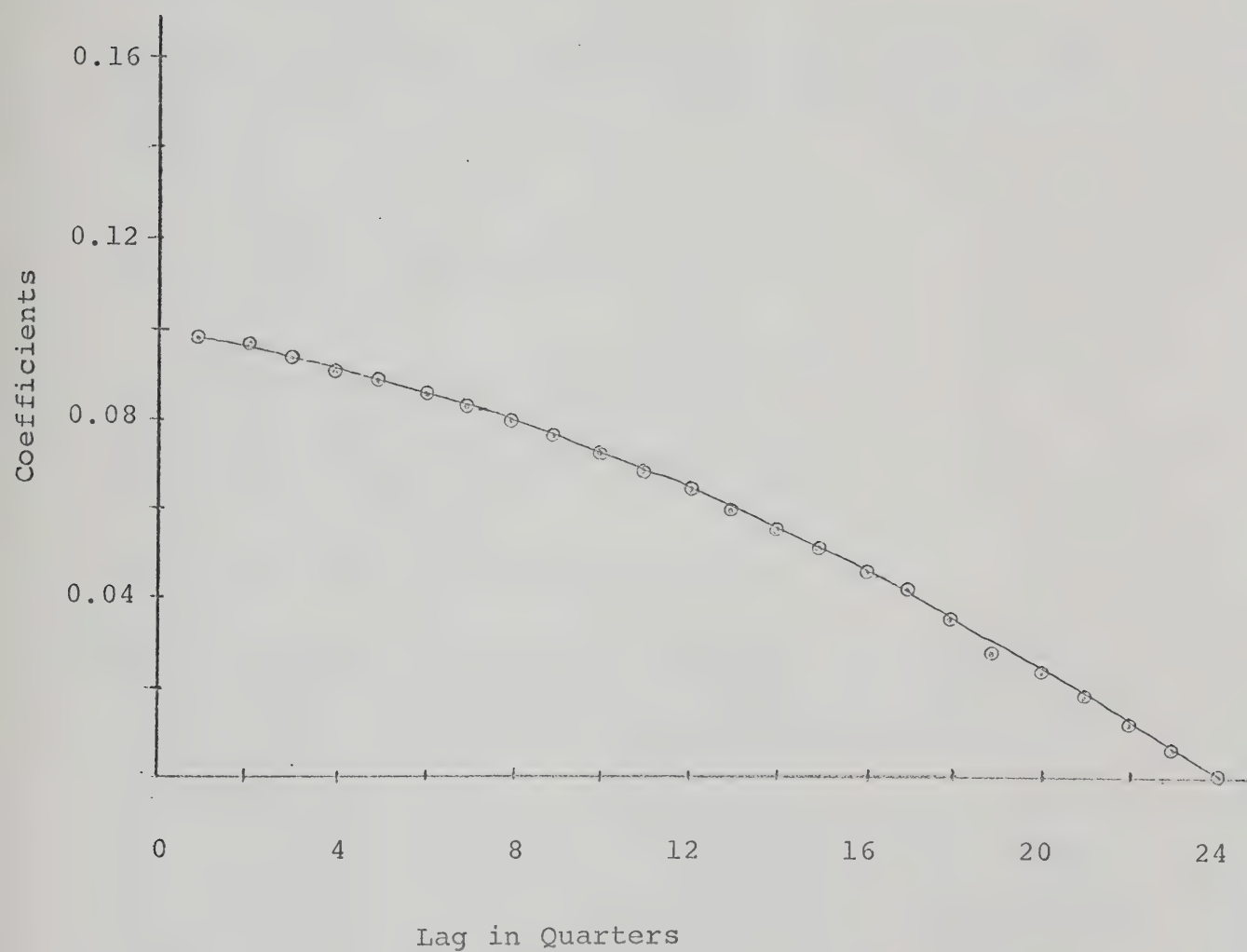


Figure 2

Distributed lag for (2,24) for the period
1953:1 to 1968:4

$$\text{INF } 1 = \frac{(Pl_t - Pl_{t-1})}{Pl_{t-1}} \quad 100$$

Pl is the implicit price deflator for gross national product.

$$\text{INF } 2 = \frac{(CPI_t - CPI_{t-1})}{CPI_{t-1}} \quad 100$$

CPI is the consumer price index

$$\text{and INF } 3 = \frac{(WPI_t - WPI_{t-1})}{WPI_{t-1}} \quad 100$$

WPI is the wholesale price index.

Results: Lower R^2 in all three cases as compared to the equation with INF. Also the sum of lagged co-efficients is smaller.

The equation with WPI gives the worst results of the three equations in the sense of giving the least effect of expected rate of inflation on interest rates. $\sum_{j=0}^{15} a_j = 0.365$ which implies a very slight effect of the rates of inflation on interest rate. A one percent permanent increase in the annual rate of inflation would increase the rate of interest by 0.09 percent, i.e. almost no effect. Not only is the current rate of inflation insignificant, but also the past seven quarterly rates of inflation are insignificant too. The coefficients of rates of inflation first fall, then rise and then fall again. Mean lag is about 7.72 quarters and $R^2 = 0.9904$.

The equation with the implicit price deflator for gross national product gives a larger effect of price changes on interest rates than the equation with WPI but still much smaller than the equation with the implicit price deflator for consumer expenditure component of gross national product; $\Sigma a_j = 0.636$. Only the current and the past two rates of inflation are insignificant. Mean lag is 6.61 quarters. Lag coefficients first rise and then fall; $R^2 = 0.9896$. The income variable is not significant.

The equation with the consumer price index works quite well though not as well as the one with the implicit price deflator for the consumer expenditure component of gross national product. R^2 is almost the same as in case of INF. Σa_j is smaller, equal to 1.10 and the current and the past two rates of inflation are not significant. However, it works much better in every respect than the equations with implicit price deflator for gross national product or with wholesale price index. Mean lag is equal to 7.08 quarters.

Therefore, as compared to the other proxies for price variable, the one selected by us initially works best empirically.

4.3 The Final Equation

Since we have chosen 16 quarters as the length of the lag on the basis of experimentation over the common data set 1953:1 to 1968:4, we can now estimate equation (3,16)

over the larger data set 1951:1 to 1968:4, that is over 72 observations, to get the final equation.

$$RL = -2.46 + 0.05 Q_1 - 0.06 Q_2 - 0.10 Q_3$$

$$(-1.79) \quad (1.8) \quad (-2.4) \quad (-2.97)$$

$$+ 1.07 \log PCPGNER - 3.3 \log RPCHPM$$

$$(4.05) \quad (-4.28)$$

$$+ 0.37 CHRL + 0.49 USRL + 0.04 INF + \sum_{j=1}^{15} a_j INF_{t-j}$$

$$(6.08) \quad (5.7) \quad (2.17)$$

$$\sum_{j=0}^{15} a_j = 1.32$$

$$R^2 = 0.9935$$

$$D.W. = 1.17$$

$$\text{Mean lag} = 6.69 \text{ quarters}$$

$$\rho = 0.95$$

$$a_1 = 0.060 \quad (3.0)$$

$$a_9 = 0.110 \quad (5.8)$$

$$a_2 = 0.071 \quad (3.9)$$

$$a_{10} = 0.105 \quad (5.9)$$

$$a_3 = 0.082 \quad (4.5)$$

$$a_{11} = 0.098 \quad (5.9)$$

$$a_4 = 0.091 \quad (4.8)$$

$$a_{12} = 0.087 \quad (5.8)$$

$$a_5 = 0.099 \quad (5.0)$$

$$a_{13} = 0.072 \quad (5.6)$$

$$a_6 = 0.105 \quad (5.2)$$

$$a_{14} = 0.053 \quad (5.4)$$

$$a_7 = 0.109 \quad (5.5)$$

$$a_{15} = 0.029 \quad (5.2)$$

$$a_8 = 0.111 \quad (5.7)$$

The graph of the distributed lag is given in Figure

3.

Results show that about 99.35 percent of the total

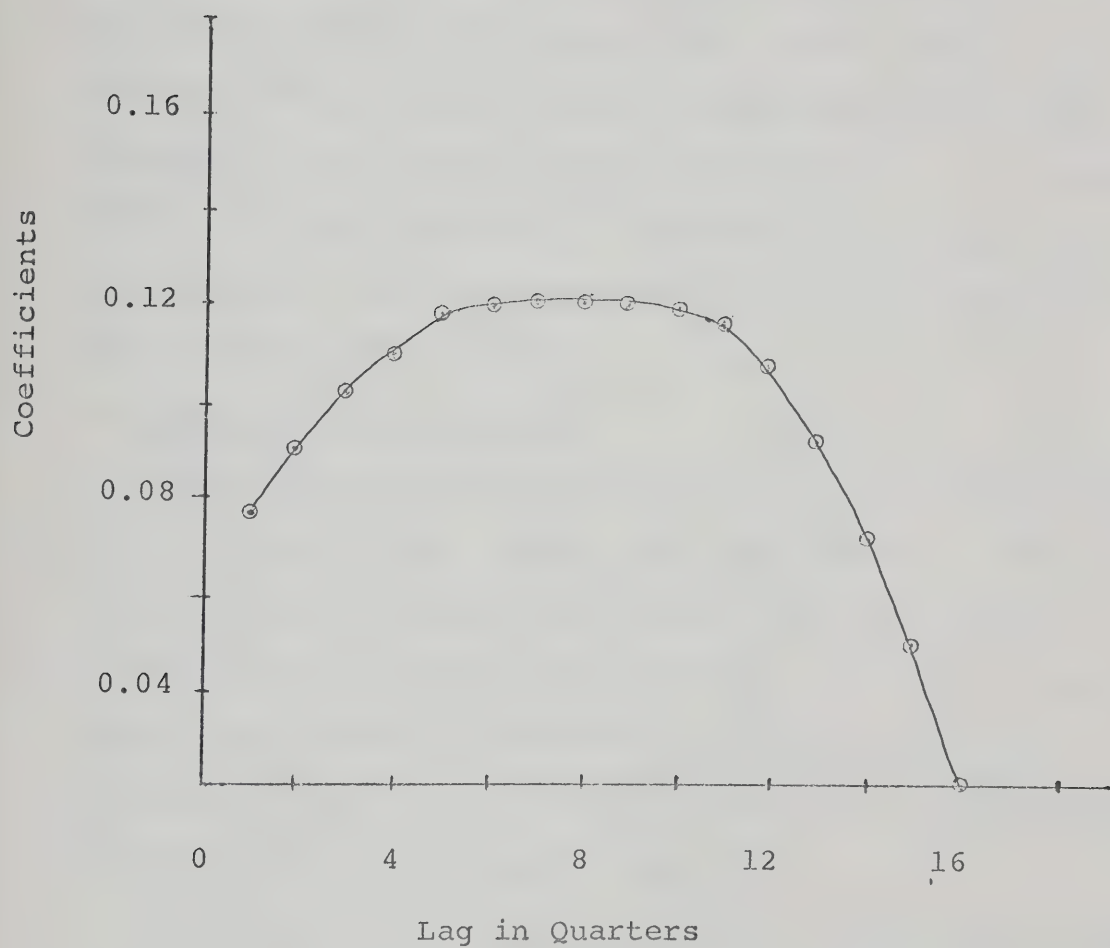


Figure 3

Distributed lag for (3,16) for the
period 1951:1 to 1968:4

variation in long-term interest rate can be explained by our model. All the variables have the expected signs and are significant. Rates of inflation have a positive and significant effect on interest rate. Mean lag is 6.69 quarters. $\Sigma a_j = 1.32$, that is, a permanent one percent increase in the annual rate of inflation (a 0.25 percent increase in quarterly rate) increases the interest rate by 0.33 percent. Thus the real rate of interest falls as the rate of inflation increases.

4.4 Some Other Experiments

i It is quite possible that our measure of price expectations (based on the current and past rates of inflation) is not adequate. Price expectations may also depend on the policy measures taken by the government to affect total demand, the measures of economic activity, and so on. This may partly be the reason why we did not get a higher effect of price changes on interest rates.

According to Andersen and Carlson, "since price changes tend to lag behind changes in total spending, the degree of resource utilization, as measured by the unemployment rate, is used as a leading indicator of future price movements." [2, p. 13]. They, therefore, adjusted the rates of price change by the index of unemployment rate and used this in place of unadjusted rates of price change.

In order to see whether the adjusted rates of inflation would give a higher effect of price expectations on nominal

rates, we re-estimated our equation, using the rates of inflation divided by the index of unemployment rate, for the period 1953:1 to 1968:4. Results were not satisfactory. The coefficients of income, liquidity, short-run expectations had wrong signs and were insignificant. Only the U.S. interest rate was significant. R^2 was 0.9744. D.W. was 1.17. Most of the adjusted rates of price inflation were negative. The sum of lag coefficients was -0.33.

Estimates by the use of Cochrane-Orcutt option were more satisfactory though not as satisfactory as our original ones. The estimated equation was

$$RL = -0.48 + 0.04 Q_1 - 0.036 Q_2 - 0.055 Q_3$$

$$(-0.21) \quad (1.07) \quad (-1.06) \quad (-1.28)$$

$$+ 0.72 \log PCPGNER - 2.8 \log RPCHPM + 0.34 CHRL$$

$$(1.99) \quad (-3.02) \quad (4.88)$$

$$+ 0.53 USRL + 0.029 INFDUR + \sum_{j=1}^{15} a_j INFDUR_{t-j}$$

$$(5.06) \quad (1.37)$$

$$\sum_{j=0}^{15} a_j = 0.41$$

$$R^2 = 0.9906$$

$$D.W. = 1.0759$$

$$\text{Mean lag} = 9.53 \text{ quarters}$$

$$a_1 = 0.044 \quad (1.6)$$

$$a_4 = -0.009 \quad (-0.3)$$

$$a_2 = 0.015 \quad (0.6)$$

$$a_5 = -0.009 \quad (-0.3)$$

$$a_3 = -0.001 \quad (-0.1)$$

$$a_6 = -0.004 \quad (-0.1)$$

$a_7 = 0.006 (0.2)$	$a_{12} = 0.058 (2.0)$
$a_8 = 0.018 (0.6)$	$a_{13} = 0.057 (2.2)$
$a_9 = 0.030 (1.0)$	$a_{14} = 0.048 (2.4)$
$a_{10} = 0.043 (1.4)$	$a_{15} = 0.030 (2.5)$
$a_{11} = 0.053 (1.7)$	

INFDUR is equal to $\frac{INF}{UR/4}$, where $UR/4$ is the

index of unemployment as a percent of labour force (base = 4.0).

Most of the adjusted rates of price change were insignificant. A few were negative. A one percent permanent increase in the adjusted rate of inflation would increase the nominal interest rate by 0.10 percent only.

Thus our original measure of price expectations gave better results than the measure proposed and used by Andersen and Carlson.

ii It is possible that the relationship between Canadian and U.S. interest rates was less close during the period of flexible exchange rates than during the period of pegged exchange rates. In order to have a more correct specification of the model, therefore, the change in the relationship should be explicitly considered. This is done by using a dummy variable Z_1 whose value is 0 during the flexible exchange rate period, and is one during the period of pegged exchange rates. The model is, therefore

$$RL = A_0 + A_1 Q_1 + A_2 Q_2 + A_3 Q_3 + b \log PCPGNER$$

$$+ c \log RPCHPM + d CHRL + e USRL + f Z1 (USRL)$$

$$+ a_0 INF + \sum_{j=1}^{n-1} a_j INF_{t-j} + \mu$$

It is expected that f is positive.

The equation was estimated for the period 1951:1 to 1968:4 for (3, 16). Results showed high positive autocorrelation of errors, so the Cochrane-Orcutt option was used.

The estimated equation is

$$RL = -2.3 + 0.05 Q_1 - 0.06 Q_2 - 0.1 Q_3 + 1.0 \log PCPGNER$$

(-1.7) (1.86) (-2.2) (-2.9) (3.8)

$$- 3.09 \log RPCHPM + 0.33 CHRL + 0.50 USRL$$

(-4.0) (5.37) (5.91)

$$+ 0.05 Z1 (USRL) + 0.04 INF + \sum_{j=1}^{15} a_j INF_{t-j}$$

(2.07) (2.21)

$$\sum_{j=0}^{15} a_j = 1.26$$

$$R^2 = 0.9939$$

$$D.W. = 1.266$$

$$\text{Mean lag} = 6.7 \text{ quarters}$$

All the coefficients of price changes were positive and significant.

As expected, f was positive and significant, which shows that Canadian interest rates were more closely related to U.S. rates during the pegged exchange rate

period rather than during the period of flexible exchange rates. When the closer relationship between the U.S. and Canadian rates during the pegged exchange rate period was taken into account, there was little change in the price expectations effect. The price changes still had a positive and significant effect on nominal interest rates. A permanent one percent increase in the rate of inflation increased the nominal interest rate by 0.315 percent.

iii As Feldstein and Eckstein have pointed out, "It is of course well known that the liquidity preference and loanable funds theories are equivalent alternatives in comparative static analysis. However in specifying a dynamic adjustment equation in a complete model, there is potential scope for elements of both theories. More specifically, the components of the demand and supply for loanable funds that are either insensitive to the interest rate or that react to interest changes only with a lag of more than one quarter can legitimately be incorporated into such a dynamic interest rate equation." [20, p. 369-370]. However, when Feldstein and Eckstein included real per capita personal and corporate savings, real per capita government deficit, and real per capita non-residential investment, these flow variables were found to make no meaningful contribution to the analysis of long-term interest rate movement.

When we included these flow variables in our model,

results (for 1951:1 to 1968:4) were unsatisfactory. The coefficient of saving was positive and insignificant, while investment was found to have a negative and significant effect on interest rate, which does not make much sense. $\sum_{j=0}^{15} a_j = 0.47$ implied a very slight effect of price expectations on interest rate. The current rate of inflation had a negative and insignificant effect. The low value of Durbin-Watson statistic indicated the presence of autocorrelation.

The Cochrane-Orcutt technique gave the following results

$$RL = -2.8 + 0.006 Q_1 - 0.12 Q_2 - 0.17 Q_3 + 0.55 \log PCPGNER$$

$$(-1.86) (0.1) \quad (-2.6) \quad (-2.2) \quad (1.3)$$

$$- 3.1 \log RPCHPM + 0.35 CHRL + 0.50 USRL + 1.65 RPCS$$

$$(-3.8) \quad (5.7) \quad (5.7) \quad (1.35)$$

$$+ 3.27 RPCGSOD + 1.27 RPCNRI + 0.035 INF$$

$$(1.48) \quad (0.54) \quad (1.7)$$

$$+ \sum_{j=1}^{15} a_j INF_{t-j}$$

$$\sum_{j=0}^{15} a_j = 1.30$$

$$R^2 = 0.9938$$

$$D.W. = 1.1746$$

$$\text{Mean lag} = 6.69 \text{ quarters}$$

$$a_1 = 0.057 \quad (2.82)$$

$$a_2 = 0.070 \quad (3.78)$$

$$a_3 = 0.081 \quad (4.39)$$

$$a_4 = 0.091 \quad (4.75)$$

$$a_5 = 0.099 \quad (5.01)$$

$$a_6 = 0.105 \quad (5.24)$$

$$a_7 = 0.109 \quad (5.45)$$

$$a_8 = 0.110 \quad (5.62)$$

$$a_9 = 0.109 \quad (5.75)$$

$$a_{10} = 0.105 \quad (5.80)$$

$$a_{11} = 0.097 \quad (5.76)$$

$$a_{12} = 0.086 \quad (5.66)$$

$$a_{13} = 0.071 \quad (5.49)$$

$$a_{14} = 0.052 \quad (5.27)$$

$$a_{15} = 0.028 \quad (5.04)$$

Where RPCS is real per capita personal and business saving. RPCGSOD is the real per capita government surplus. RPCNRI is the real per capita non-residential investment.¹

Saving and government surplus variables had the wrong sign and were insignificant. Investment variable was found to be insignificant. Thus, it was found that the savings, investment and the government surplus variables did not make a significant or a meaningful contribution to the analysis of interest rate determination. However,

$$^1 \quad \text{RPCS} = \frac{\text{PS} + \text{BGSUP} + \text{BGSCCA} + \text{BGSAGT}}{\text{Pl} \cdot \text{POP}}$$

$$\text{RPCNRI} = \frac{\text{CFMER} + \text{CFNCR}}{\text{POP}}$$

$$\text{RPCGSOD} = \frac{\text{GSOD}}{\text{Pl} \cdot \text{POP}}$$

These variables are described in the Appendix.

even when these variables were included the effect of rates of inflation was not diluted. The sum of coefficients of price changes, as well as the mean lag were unchanged.

iv

Our model includes lagged dependent variables in the form of CHRL which is $RL_t - RL_{t-1}$. The simultaneous presence of lagged dependent variables and autocorrelated disturbances results in biased estimates. We are interested mainly in the effect of price expectations on nominal interest rates. In order to see if the coefficients of rates of inflation will be much changed if we excluded CHRL and thus removed the bias, (though some bias might arise from leaving out a relevant variable) we re-estimated (3,16) for 1951:1 to 1968:4 by Cochrane-Orcutt iteration procedure. The estimated equation was

$$RL = -3.86 + 0.04 Q_1 - 0.08 Q_2 - 0.09 Q_3 + 1.0 \log PCPGNER$$

$$(-2.09) \quad (1.29) \quad (-2.28) \quad (-2.12) \quad (3.04)$$

$$- 3.2 \log RPCHPM + 0.75 USRL + 0.05 INF$$

$$(-3.3) \quad (7.87) \quad (2.26)$$

$$+ \sum_{j=1}^{15} a_j INF_{t-j}$$

$$\sum_{j=0}^{15} a_j = 1.18$$

$$R^2 = 0.9894$$

$$D.W. = 1.8156^1$$

$$\text{Mean lag} = 6.7 \text{ quarters}$$

All the lagged rates of inflation were significant. Mean lag was the same as in the case of equation with CHRL. Σa_j was, however, smaller. It was equal to 1.18 as compared to 1.32 in the equation with CHRL. Therefore, price expectations were found to have a positive and significant effect on nominal interest rates even when CHRL was left out.

v According to Stanely Diller, in the National Bureau of Economic Research occasional paper 108, "there are no obvious reasons for seasonality in long-term rates and cogent reasons for its absence. To meet seasonal needs for cash corporations, including banks, seldom sell off long-term securities and thereby raise rates. Firms, moreover, can usually delay their long-term borrowing to take advantage of seasonal (i.e., expected) declines in rates; and in so doing eliminate the seasonal variations. Finally, seasonality of sufficient amplitude would invite arbitrage, that is investors would buy bonds when rates were high and sell them, say, six months later when rates

¹ It may be noted that leaving out CHRL resulted in an improvement in the Durbin Watson statistic when Cochrane-Orcutt method was used though some positive autocorrelation still existed.

fell--reducing their incentive in the process."¹ [16, p. 9]. However, he found significant seasonal movements in all of the U.S. long-term securities examined, though the seasonal amplitude of long-term rates was found to be smaller than that of short-term rates.

We found the second and third quarter dummies to be significant. Some of the seasonal variation in the Canadian long-term rate may be explained by the seasonal variation in U.S. rate and perhaps by the seasonal movements in INF. Since the U.S. interest rate and INF have already been included as explanatory variables, and since there does not seem to be any other obvious reason for seasonality in Canadian long-term rates, it can be argued that there is no need to include seasonal dummies as explicit independent variables. To see the effect of excluding seasonal dummies, we reestimated our equations (3,16), (4,16) and (2,24) for the period 1953:1 to 1968:4 without seasonal dummies.

¹ He pointed out, however, that a seasonal variation in long-term bonds can survive arbitrage so long as the amplitude does not exceed some specified amount. This amount will be greater the more important is the irregular component of the series, the shorter is the maturity of the bond, and the greater is the margin requirement for borrowing money to purchase bonds. [16, p. 100].

In all cases, the mean lag increased and $\sum_{j=0}^{n-1} a_j$ decreased as a result of ignoring the seasonal dummies, though for (2,24), the difference was not as much as in the other two cases. For (3,16), mean lag increased from 18.25 to 25.13 quarters and $\sum a_j$ decreased from 0.20 to 0.12. Estimates by the Cochrane-Orcutt method also showed a similar pattern. For (3,16), the mean lag increased from 6.95 to 18.17 quarters and $\sum a_j$ fell from 1.22 to 0.18. While all a_j s were positive for (3,16) when seasonal dummies were included, a_1 to a_7 became negative when seasonality was not explicitly taken into account. Therefore, it seems that seasonal dummies play an important role in our model which is hard to explain.

It was also found that excluding the seasonal dummies resulted in a rise in the coefficient of the U.S. long-term rate in all cases. For example, the coefficient of USRL increased from 0.52 to 1.29, for (3,16) estimated by the Cochrane-Orcutt method, as a result of leaving seasonal dummies out of the regression equation. Therefore, it seems that the exclusion of dummy variables leads to an overestimate of the effect of U.S. interest rate on Canadian interest rate.

The important role of seasonal dummies in our model is all the more interesting since all the other studies on price expectations effect (except the Yohe-Karnosky study which tried seasonally adjusted as well as unadjusted

interest rate series. They used annual rates of inflation, so they did not need to adjust the rate of inflation series) have used seasonally unadjusted data but have not introduced seasonal dummies. Feldstein and Eckstein did not use seasonally adjusted data except for the monetary base; yet they did not include seasonal dummies.

CHAPTER V

CONCLUSIONS AND IMPLICATIONS

i The study shows that in Canada the changes in the rates of inflation do affect nominal interest rates. A permanent one percent increase in the annual rate of inflation (or a 0.25 percent increase in the quarterly rate) raises the nominal interest rate by approximately 0.33 percent in 16 quarters. Therefore, the real rate of interest falls as a result of the increase in the rate of inflation.¹

ii Although our study indicates that price changes have a positive and a very significant effect on the nominal interest rate, the effect is smaller than that found by Carr and Smith. They found that a one percent permanent increase in the annual rate of inflation raises the long-term interest rate by one percent.

One possible explanation for the difference in the magnitude of price expectations effect in the two studies may be that the data period is different. Our estimates are based on the observations over almost the last two decades, from 1951:1 to 1968:4, while the estimates of their study are based on observations over the period 1958:1 to 1969:4. It may be hypothesized that in the

¹ As pointed out by Fisher, one consequence of the inadequacy of the interest rate adjustment to price movements

'sixties, because of institutional changes or the explicit recognition of price inflation as a permanent factor, price changes have come to have a more substantial effect on interest rates. This hypothesis was found to be true for United States by Yohe and Karnosky. We re-estimated our equation (3,16) separately for the shorter data periods 1951:1 to 1959:4 and 1960:1 to 1968:4, by the Cochrane-Orcutt option to test the hypothesis. We found that price expectations did have a more substantial effect on the nominal interest rates in the 'sixties than in the 'fifties. The sum of the co-efficients of current and lagged rates of inflation was 2.59 for the period 1960:1 to 1968:4, implying that a one percent permanent increase in the annual rate of inflation would raise the nominal interest rate by 0.65 percent. The price expectations effect was much smaller in the earlier period. The sum of coefficients of the rates of price changes was 1.04, implying that a permanent one percent increase in the rate of inflation would raise the long-term interest rate by only 0.26 percent. Mean lag was almost the same--about 7 quarters for both periods. For the earlier period, the current and one quarter lagged rates of inflation were found to be

is that "a large amount of wealth is continually and unintentionally transferred from the creditor to the debtor class, and vice versa." [22, p. 287].

insignificant, while for the later period, all the sixteen quarterly rates of price change were found to be significant. Therefore, the effect of price expectations on interest rates seems to have increased greatly in the sixties and this partly explains why the price expectations effect in the Carr and Smith study was greater than that found in our study.

Another reason for the larger price expectations effect in the Carr and Smith study may be that their model is not a complete model of the interest rate determination. They have not included income, short run expectations and the United States interest rate in their regression, so the coefficients of price changes in their equation may be biased upwards, reflecting partly the positive effect of these left out variables on the interest rate. Particularly, leaving out the United States interest rate, which was found to have a very significant positive effect on nominal rates in this study, may have biased the price expectations effect upwards in the Carr and Smith study.

We checked this out by dropping variables from our equation. We found that $\sum_{j=0}^{n-1} a_j$ increased from 0.20 to 1.47 in case of equation (3,16) for the period 1953:1 to 1968:4 when we dropped USRL from the equation and further to 1.55 when CHRL was also dropped. Similarly, in the case of equation (2,24), the sum of co-efficients increased from 0.50 to 2.34 when USRL was dropped and to

2.67 when CHRL was also dropped. When the Cochrane-Orcutt method was used, we again found that price expectations effect increased as a result of dropping USRL and CHRL. For example, in the case of (3,16), $\sum_{j=0}^{15} a_j$ increased from 1.22 to 1.73 as a result of ignoring USRL and to 1.96 as a result of excluding CHRL too.

Re-estimating equation (3,16) for the period 1960:1 to 1968:4 by Cochrane-Orcutt method while ignoring USRL and CHRL, we found the price expectations effect to be still higher. The sum of the co-efficients of current and lagged rates of price inflation was 3.75, implying that a permanent one percent increase in the annual rate of inflation would raise the nominal interest rate by approximately 0.94 percent.¹

iii Many studies for the United States, for earlier historical periods, found very long lags for the effect of price changes on nominal interest rates. The lags were so long that the recent price behaviour could be ignored in evaluating the changes in nominal interest rates. However, a few studies for the more recent periods for United States as well as the only study for Canada indi-

¹ It was noted again that when CHRL was left out of the equation, and the Cochrane-Orcutt option was used to estimate the equation, we got a higher Durbin-Watson statistic (ranging from 1.6 to 2.0).

cate much shorter mean lags. Our results about the average lag for the price expectations effect in Canada similarly show short mean lags--less than two years (as compared with the mean lag of eleven quarters in Carr and Smith study). The shorter lags generally found for recent periods may mean that in the last two decades, price changes have come to have a prompter effect on interest rates.

The continuing inflation in recent periods, the greater publicity given to price movements, and the more rapid processing of price data might have resulted in a greater awareness of the recent price changes. The prompter effect of price movements on nominal interest rates in recent periods may also be due to the post-war increase in the degree of financial market perfection and its consequent effect on interest rate flexibility.

iv

It may also be noted that not only does there exist a positive relationship between inflationary expectations in Canada and the Canadian interest rate, but also there would seem to exist a positive but indirect relationship between price expectations in the United States and Canadian interest rates. Feldstein-Eckstein found that a permanent one-percent increase in the annual rate of inflation would raise the long-term interest rate in the United States by 0.92 percent. Also, we have seen that there exists a positive and significant relationship between U.S.

and Canadian interest rates. A one percent increase in the U.S. long-term interest rate, in our final equation, was found to raise the Canadian long-term interest rate by 0.49 percent. Therefore, an increase in the expected rate of inflation in the United States would increase the U.S. interest rate which would in turn increase the Canadian interest rate.

v¹

Canadian monetary policy can be criticized in view of the implications of the positive relationship between price expectations and the nominal rate for the use of nominal interest rates as an indicator of monetary policy.²

According to Courchene, "Canadian monetary policy is calibrated with reference to conditions relating to nominal rates of interest and the availability of credit" [14]. This, he says, is clear in the words of the Governor "The Bank regards its chief function in the field of monetary policy as being to help bring about the kind of credit conditions that are appropriate to domestic economic conditions and to the maintenance of the country's external financial position. By credit conditions I mean the cost

¹ This section is largely based on Courchene's discussion of "Recent Canadian Monetary Policy" [14].

² The implications of Fisher Effect for the use of nominal interest rates as an indicator of monetary policy under inflationary conditions have already been noted in Chapter I.

and availability of money throughout the economy In the day to day determination of monetary policy, the central bank is not primarily influenced by considerations relating to the size of money supply." [45]. He has also noted that the Bank seems to identify rising nominal rates with tightening of credit conditions.

Rates of monetary expansion in Canada have been very high in recent years. The rate of expansion of the privately held bank money was 12 1/2 percent in 1965, which was twice the rate in 1964, but lower than the rate of 16.9 percent in 1967. In the second quarter of 1968, privately held bank money rose at an annual rate of 23 percent. Interest rates at the same time increased rather than decreased as a result of these policies. According to Courchene, "In large measure these policies were a result of focusing on nominal rates of interest in particular and credit conditions in general as the indicators of monetary policy." ". . . . calibrating monetary policy with reference to nominal interest rates was one of the major errors of Bank policy over this period." [14, pp. 40, 51].

vi

Nominal interest rates are considered to be a measure of the cost of capital. The use of interest rates as a target of monetary policy is based on this concept. Monetary policy is often used in order to affect investment expenditures through affecting capital costs. However,

in the light of our results about the relationship between the nominal rate of interest and the expected rate of inflation, it is not clear that a higher nominal interest rate would necessarily restrict investment expenditures. Many studies have found business investment to be insensitive to changes in the interest cost. One of the reasons for this may be the existence and recognition of an inflation premia built into the nominal interest rate. In fact, if investors expect a higher rate of inflation, they may be willing to invest more rather than less even in the face of higher nominal rates. As Gestrin has pointed out, there is a "problem of a strong credit demand in the face of record high interest rates in many countries implying that very few participants in the capital market focus on nominal rather than on the real cost of capital [27, p. 30]. In Canada, "the record high interest levels have not until recently deterred those borrowers who have expected prices to go on rising at 4-5 percent per annum." [27, p. 29].

vii As suggested by Fand, it is possible that the household sector's elasticity of expectation is lower than that for business sector. The household sector may accept the market (nominal) interest rates as a proxy for the real rates and thus act on the basis that real rates have been rising, while the "corporate officials responsible for investment decisions may have more fully articulated price expectations and in spite of the rapid rise in mar-

ket rates may have concluded that the real cost of capital is low." [18, p. 110]. This may be the reason why residential construction has been found to be interest elastic while business investment is not so responsive to changes in nominal interest rates.

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APPENDIX

Description and Sources of Data

Data for all the variables, except for the United States interest rate, was taken from the Bank of Canada Massager Tape. The original sources for the series are also given on the tape. For many series the original source is National Accounts, Income and Expenditure, 13-001 DBS. For other series the source will be specifically given.

BGSUP	Business gross saving, undistributed corporation profits. Million dollars (D 358).
BGSCCA	Business gross saving, capital consumption allowances. Million dollars (D 359).
BGSAGT	Business gross saving, adjustment on grain transactions. Million dollars (D 360).
CEM	Personal expenditure on consumer goods and services. Million dollars (D 201).
CER	Personal expenditure on consumer goods and services in constant, 1957, dollars. Millions (D 241).
CFMER	Business gross fixed capital formation, new machinery and equipment in constant, 1957, dollars. Millions (D 245).
CFNCR	Business gross fixed capital formation, new non-residential construction, in constant, 1957, dollars. Millions (D 244).
CPI	Consumer Price Index (D 1777). Source: Prices and price indexes. % 62-002<, DBS.
GER	Government expenditure on goods and services in constant, 1957, dollars. Millions (D 242).

GNEM	Gross national expenditure at market prices. Million dollars (D 210).
GNER	Gross national expenditure in constant, 1957, dollars. Millions (D 250).
GSOD	Government surplus or deficit. Million dollars (D 362).
HPM1	Total Canadian cash reserves of Canadian char- tered banks. Million dollars (D 4193). Source: Statistical Summary of Bank of Canada. Bank of Canada deposits are averages of the juri- dicial days in the month shown while Bank of Canada notes are averages of the 4 consecutive Wednesdays ending with the second last Wednesday in the previous month. Monthly figures were averaged to get quarterly data.
HPM2	Total currency outside banks. Million dollars (D 4261). Average of Wednesdays. Source: Statistical summary of Bank of Canada. Quarterly figures are averages of monthly data.
POP	Population of Canada. Thousands (D 1). Source: Estimated population of Canada by pro- vinces % 91-201<, D.B.S. Quarterly data relate to January 1, April 1, July 1, and October 1.
PS	Personal saving. Million dollars (D 324).
RL	Long-term Government of Canada bond yield average. Percent (B 14003). Source: Bank of Canada, Statistical Summary and Supplements. Arithmetic average on all direct Government of Canada bonds denominated in Canadian dollars, due or callable in 10 years or more, excluding perpetuials. Till 1957, monthly figures are averages of yields at mid and end month. Since 1958, monthly figures are the averages of Wednesday yields calculated from mid-market closing prices. Quarterly figures are averages of monthly figures.
UR	Canada unemployment rates. (D 1097). Source: Labour Force Bulletin, 71-001, D.B.S. The unemployed as a percentage of the labour force.

USRL U.S. long-term Government bond yield.
Source: International Financial Statistics.
Monthly figures were averaged to get quarterly
data.

WPI General Wholesale Price Index (D 1733).
Source: Price and Price Indexes % 62-002<,
D.B.S.

B29999